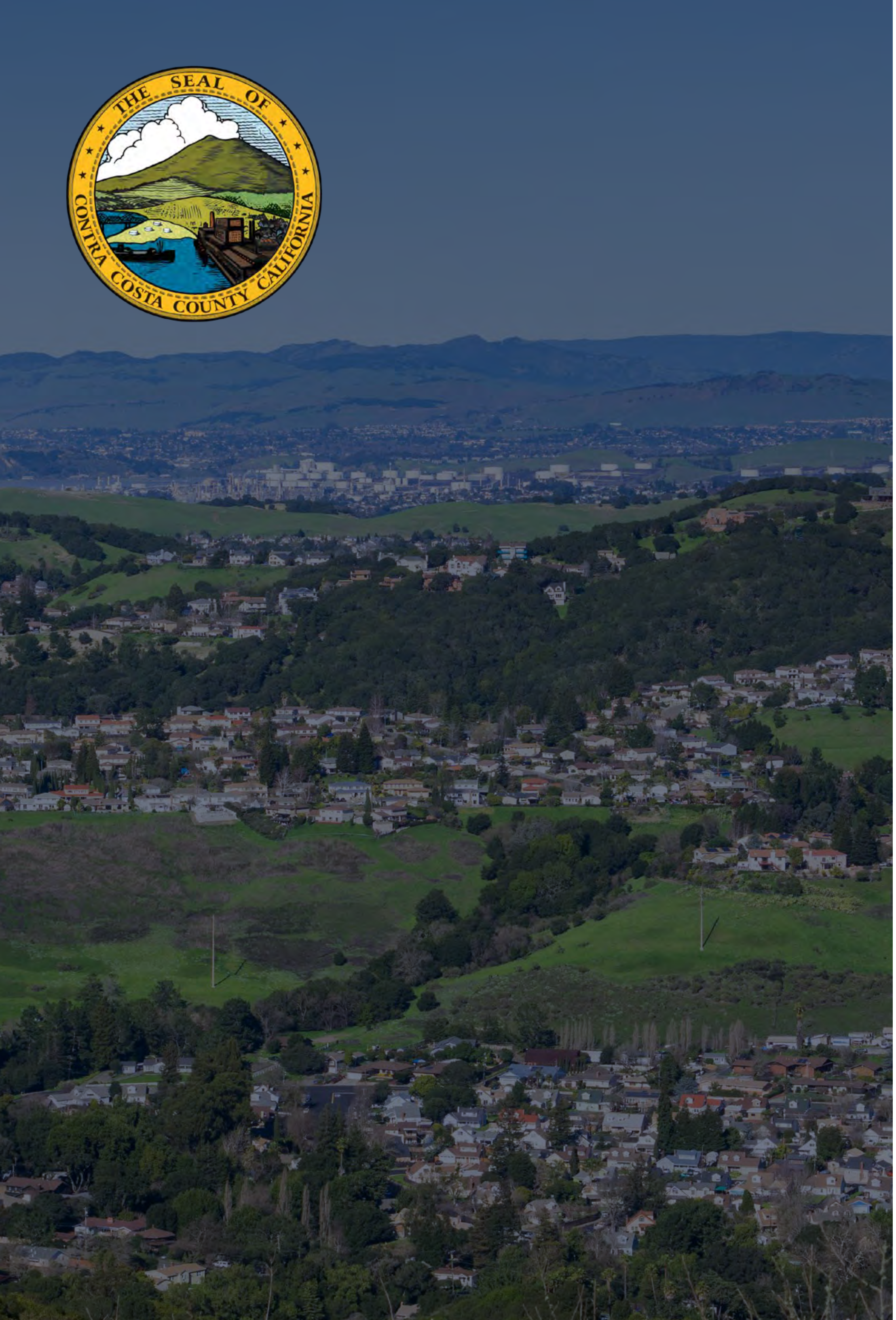

Contra Costa County

Healthy Lands, Healthy People:

A Carbon Sequestration Feasibility Study

September 2023

ACKNOWLEDGEMENTS

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The work upon which this publication is based was funded in whole or in part through a grant awarded by the California Department of Conservation.

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G.

GLOSSARY

C

CALIFORNIA AIR RESOURCES BOARD (CARB) – CARB is charged with protecting the public from the harmful effects of air pollution and developing programs and actions to fight climate change. CARB's mission is to promote and protect public health, welfare, and ecological resources through effective reduction of air pollutants while recognizing and considering effects on the economy. CARB is the lead agency for climate change programs and oversees all air pollution control efforts in California to attain and maintain health-based air quality standards.

CALIFORNIA AIR RESOURCES BOARD (CARB) LAND RESTORATION BENEFITS CALCULATOR – A tool to estimate the net greenhouse gas benefit and selected co-benefits of each proposed Land Restoration project type used by Programs funded by the Greenhouse Gas Reduction Fund.

CALIFORNIA AIR RESOURCES BOARD (CARB) SCOPING PLAN – Lays out a path to achieve targets for carbon neutrality and reduce anthropogenic greenhouse gas emissions by 85 percent below 1990 levels no later than 2045, as directed by Assembly Bill 1279.

CARBON NEUTRALITY – A state of net-zero carbon emissions, achieved by balancing total carbon dioxide emissions with equal removal of atmospheric carbon.

CARBON or CARBON DIOXIDE (CO_2) – A natural occurring atmospheric gas, also produced by burning fossil fuels, through land-use changes, and industrial processes.

CARBON SEQUESTRATION – Process of capturing, securing, and storing carbon from the atmosphere, for example in vegetation such as grasslands or forest, as well as in soils and oceans. This process occurs naturally and can also be facilitated by human activities.

CARBON SINK – A natural environment, such as a forest or ocean, recognized for its ability to absorb and store carbon dioxide from the atmosphere.

CARBON STOCK – The quantity of carbon contained in a "pool" or reservoir (such as vegetation, soil, rock, etc.) that accumulates or releases carbon.

CLIMATE CHANGE – A shift in local and global climate patterns, most acutely attributed to changes since the late twentieth century and increased levels of greenhouse gases, produced by the use of fossil fuels, emitted into the atmosphere.

CLIMATE SMART LAND MANAGEMENT – Managing lands to deliver climate benefits. Specific actions or practices may be called climate smart practices, and in the case of agricultural practices may be referred to as climate smart agriculture.

CO-BENEFITS – Positive benefits related to climate mitigating actions (e.g., reduced air pollution).

COMET-PLANNER – An evaluation tool designed to provide estimates of the net greenhouse gas reductions for specific agricultural management conservation practices included in the California Department of Food and Agriculture Healthy Soils Program and is intended for initial planning purposes.

CO_2e – Carbon dioxide equivalents. Greenhouse gases trap heat in the earth's atmosphere at different rates (see Global Warming Potential). Using a greenhouse gases' global warming potential, gases other than CO_2 are translated into CO_2 equivalents (CO_2e) so all greenhouse gases may be summed together.

F

FOREST – is an area of land dominated by trees. In this report, the term "forest" term is used to encompass woodlands that occur in Contra Costa, such as oak woodlands.

G

GLOBAL WARMING POTENTIAL (GWP) – The measure of how much energy the emissions of one ton of a gas will absorb, relative to the emissions of one ton of carbon dioxide. Global warming potential was developed to allow comparisons of global warming impacts of different greenhouse gases.

GREENHOUSE GAS(ES) (GHGS) – Gases that trap heat in the atmosphere (e.g., CO_2, methane, nitrous oxide, and ozone).

H

HEALTHY LANDS – refer to ecosystems, landscapes, open space, natural lands, working lands, and urban environments that can ecologically function and be resilient to climate impacts.

HEALTHY SOILS – Soils with the capacity to function as vital living ecosystems that sustain plants, animals, and humans. The principles of soil health include minimizing disturbance, maximizing biodiversity, maximizing soil cover, and maximizing living roots, all of which can increase carbon sequestration.

HEALTHY SOILS PROGRAM (HSP) – The Healthy Soils Program stems from the California Healthy Soils Initiative, a collaboration of state agencies and departments to promote the development of healthy soils on California's farmlands and ranchlands. The Healthy Soils Program has two grant programs:
1) the HSP Incentives Program which provides financial assistance for implementation of conservation management that improves soil health, sequesters carbon, and reduces greenhouse gas emissions, and 2) the HSP Demonstration Projects which showcase California farmers and ranchers' implementation of Health Soils Program practices.

I

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC) – Created in 1988 by the World Meteorological Organization (WMO) and the United Nations Environmental Programme (UNEP), the IPCC is an organization of governments that are members of the UN or WMO tasked with providing government at all levels with regular assessments of the scientific basis of climate change, its impacts and future risk, and options for adaptation and mitigation. Hundreds of experts review thousands of research papers to produce the assessment reports which serve as comprehensive summaries of what is known about climate change.

IPCC ASSESSMENT REPORT 5 (IPCC AR5) – provides the state of knowledge concerning the science of climate change. IPCC AR5 was developed by climate change experts and government representatives. The Special Report on Climate Change and Land addresses greenhouse gas fluxes in land-based ecosystems, land use and sustainable management in relation to climate change adaptation and mitigation, desertification, land degradation, and food security.

L

LAND COVER – The physical land type at a location (i.e., forest, open water).

LANDFIRE – (also known as Landscape Fire and Resource Management Planning Tools), is an interagency vegetation, fire, and fuel characteristics mapping program, sponsored by the United States Department of the Interior (DOI) and the United States Department of Agriculture, Forest Service. LANDFIRE produces a comprehensive, consistent, scientifically credible suite of geo-spatial data layers for the entire United States.

N

NATURAL AND WORKING LANDS (NWL) – Natural and working lands include forests, grasslands, shrublands/chaparral, croplands, urban green spaces, and wetlands.

NATURE-BASED SOLUTIONS (NBS) – Actions that work in accordance with nature to enhance natural systems and address societal challenges. This concept can include a range of approaches that protect, sustainably manage, and restore nature to deliver multiple outcomes, including addressing climate change, improving public health, increasing equity, and protecting biodiversity.[1] Nature-based solutions can be implemented by themselves and in combination with engineered solutions to protect and enhance performance of engineered solutions (e.g., restored oyster reef or wetlands in front of a seawall).

NATURE-BASED SOLUTIONS (NBS) BENEFITS EXPLORER – A web-based tool developed to serve as a key starting point for organizations looking to invest in nature-based solutions, and for those who want to learn more about benefit identification and accounting.

NRCS GHG AND CARBON SEQUESTRATION RANKING TOOL – A tool that provides a qualitative ranking of the benefits of a variety of agricultural practices for greenhouse gas emission reduction and carbon sequestration.

O

ORGANIC CARBON OR BIOSPHERIC CARBON – Produced by and found in living organisms including plants and soils, whereas inorganic carbon is present in minerals, rocks, and non-biologic sediments.

R

RESOURCE CONSERVATION DISTRICTS (RCDs) – RCDs are non-governmental special districts of the State of California, set up to be locally governed agencies with their own locally appointed or elected, independent boards of directors. California RCDs implement projects on public and private lands and educate landowners and the public about resource conservation. RCDs are go-to hubs for natural resource conservation and agriculture on public and private lands at local, regional, state, tribal, and federal levels.

S

SOIL ORGANIC CARBON – Soil carbon refers to solid carbon stored in soils, existing in organic and inorganic forms. Soil organic carbon is present within soil organic matter, such as plant and animal waste, microbes, and microbial byproducts. The total amount of organic carbon present in soil is one of the primary indicators of soil health.

T

TERRACOUNT – A scenario analysis tool, which was piloted for the Resilient Merced project to develop scenarios of change in land use and land management and evaluate future impacts on carbon stocks.

1. *California Natural Resources Agency (CNRA). April 22, 2022. Natural and Working Lands Climate Smart Strategy.* ***https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Expanding-Nature-Based-Solutions/CNRA-Report-2022---Final_Accessible_Compressed.pdf***

ES.

EXECUTIVE SUMMARY

PURPOSE

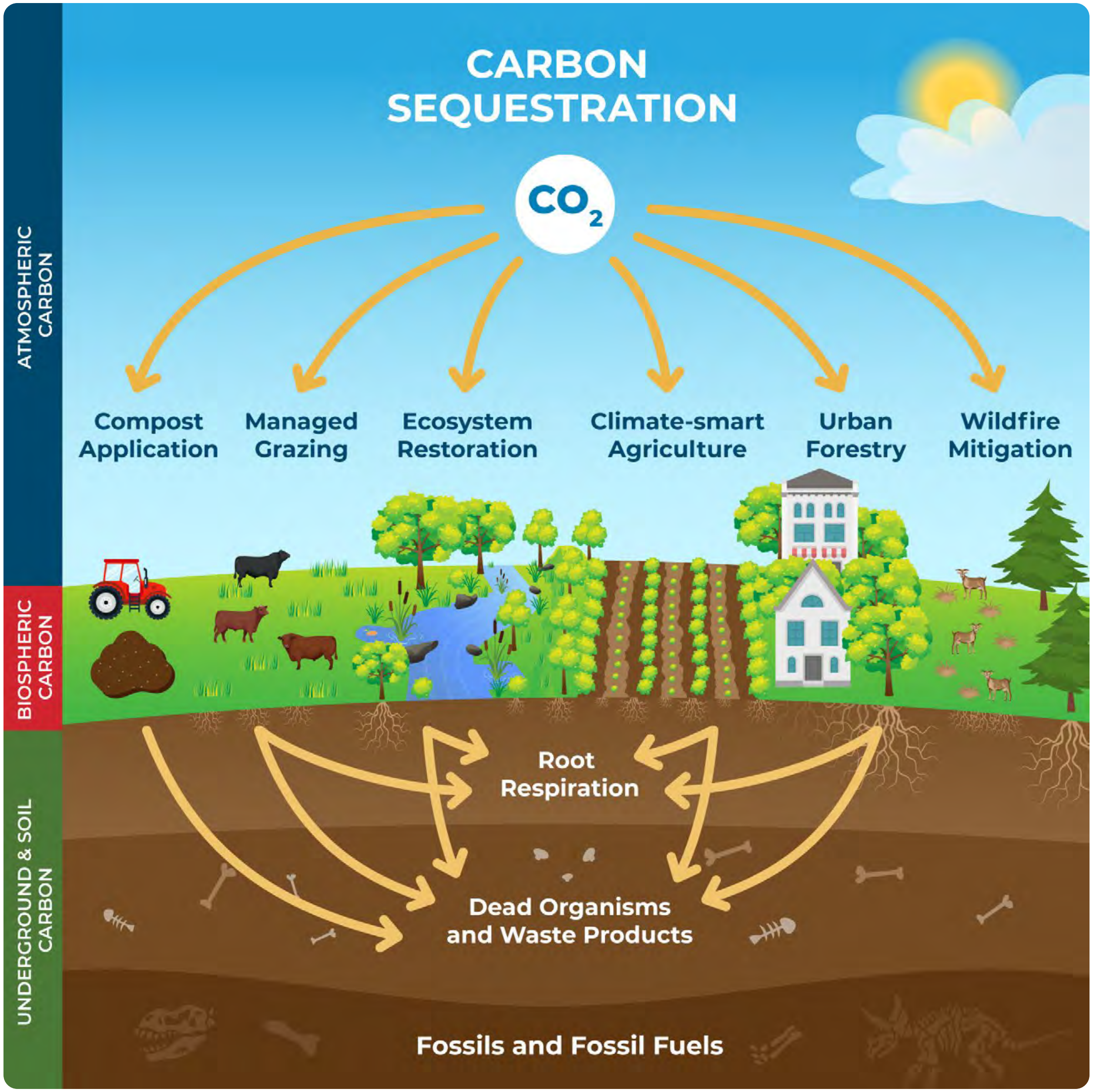
This ***Healthy Lands***, ***Healthy People: Carbon Sequestration Feasibility Study*** for the County of Contra Costa aims to provide the foundation for implementing ***nature-based solutions*** and climate smart strategies on ***natural and working lands***. This study combines the work of several County departments and partners to provide an initial understanding of the County's carbon sequestration potential, so that the County can continue to take a leadership role in lessening the impacts of a changing climate, protecting natural and working lands, and increasing the quality of life throughout the county. The findings detailed in this report are consistent with and complement the County's existing planning efforts and strategic partnerships, including the simultaneous update of the County General Plan and Climate Action Plan. The study also supports the State's ***carbon neutrality*** goals and recent legislation, specifically Assembly Bill 1757, that directs the state to determine carbon sequestration targets and tracking methodology. The measures and actions provide a roadmap towards optimizing carbon sequestration potential by restoring ***carbon*** in places where it has been lost and reduce large carbon losses on natural and working lands through active, attentive, and adaptive management.

This Healthy Lands, Healthy People project included the development of two carbon plans for urban farms, one in North Richmond and one in Pittsburg (See ***Appendix A***). Both communities are considered "disadvantaged" under the State's CalEnviroScreen tool. This project also included a series of focus groups across Contra Costa County, the results of which are provided in ***Appendix B***, and the development of a video in English and Spanish about the benefits of using natural and working lands to address ***climate change***.[1]

1 *English Video:* **https://www.youtube.com/watch?v=peKlWhznerw** *Spanish Video Final:* **https://youtu.be/dfHAHCMD2A0**

WHAT IS CARBON SEQUESTRATION AND WHY IS IT IMPORTANT?

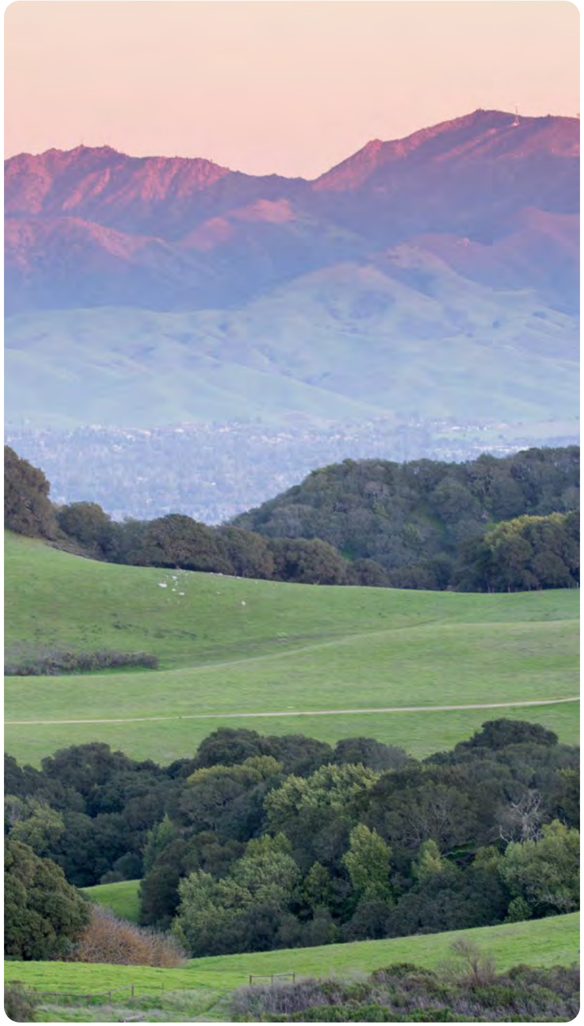
Carbon sequestration describes the process in which plants and water-based algae take carbon from the atmosphere and store it in their biomass via photosynthesis. Plants also release carbon, in the form of carbohydrates and other molecules (collectively called exudates), into the soil through their roots, where they increase ***soil organic carbon*** and support a diversity of soil microbes, which facilitate soil carbon sequestration. Natural and working lands act as a ***carbon sink*** by sequestering carbon from the atmosphere and storing it in vegetation and soils, which means they play an increasingly important role in achieving California's carbon neutrality goals. Maintaining healthy natural and working lands is key to human well-being because these lands are responsible for our agricultural abundance, water supply and quality, air quality, and biodiversity, which in turn influences socio-economics and social equity.



CARBON SEQUESTRATION ANALYSIS

Efforts to conserve, restore, and manage natural and working lands effectively require an understanding of the current land-based ***carbon stock*** and carbon sequestration potential of land management activities therein. This report provides a 2021 countywide carbon stock inventory[2] and evaluates the carbon sequestration potential and ***co-benefits*** associated with management activities for agricultural, natural, and urban lands. These activities range from improved nitrogen fertilizer management in croplands to urban forestry in developed areas. Carbon sequestration activities considered were drawn from a number of established programs and models including the CDFA Healthy Soils Program, ***TerraCount Activity Sheets***, ***COMET-Planner***, ***California Air Resources Board (CARB) Land Restoration Benefits Calculator***, and ***Natural Resources Conservation Service (NRCS) Carbon Sequestration Ranking Tool***. Carbon sequestration activities and practices were reviewed by project partners the University of California Cooperative Extension (UCCE) and ***Contra Costa Resource Conservation District (RCD)*** and by stakeholders with local knowledge and institutional expertise to evaluate the applicability to Contra Costa County. A range of potential implementation acreages was used for each carbon sequestration practice analyzed. Activities were then grouped by applicable general land uses, including row crops, orchard, vineyard, grazing, urban farm, natural lands, and urban lands.

Based on this analysis, the land management practices with the greatest carbon sequestration potential are compost application to rangelands, compost application to row crops, urban forestry, alley cropping on farms with row crops, and riparian restoration on grazing lands. Compost application can both increase the amount of carbon stored in soil, as well as increase the water holding capacity of soil and improve forage quality. The other ***climate smart land management*** practices can result in greater storage of carbon in living biomass, with a large opportunity for sequestration through expansion of trees in the developed areas of the county. Land management activities that increase carbon in vegetation must be complemented by wildfire mitigation to avoid stored carbon being emitted into the atmosphere when vegetation is burned or killed during uncontrolled wildfires.



2. *A historical county-wide carbon stock inventory was also conducted but not included in this final report. For results and discussion of the historical carbon stock inventory, see **Appendix C**, **Appendix D**, and **Appendix E**.*

MEASURES AND ACTIONS TO INCREASE CARBON SEQUESTRATION

The measures and actions below describe actions that define the specific policies, programs, and steps the County and its partners could implement to assist in reaching the state and County's 2045 carbon neutrality goal and to increase the health of the county's lands and people.

MEASURE 1: Promote Climate Smart Agricultural Practices

Action 1.1: Pursue funding (for example, California Department of Food and Agriculture [CDFA] Climate Smart Agriculture programs) and implement a voluntary agricultural conservation incentive program to encourage more farmers and ranchers to adopt conservation practices that have the potential to contribute to climate mitigation and enhance resilience of agricultural operations.

Action 1.2: Partner with the Contra Costa RCD, Contra Costa County Farm Bureau, UC Cooperative Extension, NRCS, and other stakeholders to provide outreach and education to farmers and ranchers on conservation practices that contribute to climate mitigation and increase resilience, and facilitate incentives to adopt these practices.

Action 1.3: Provide technical assistance to farmers for developing grant applications that support healthy soil practices (e.g., and compost) such as the CDFA Healthy Soils Incentive Program.

Action 1.4: Promote the development of conservation easements on natural and working lands through information sharing on the County's website, strategic partnerships, supporting community engagement efforts, and pursue funding to establish easements.

Action 1.5: Assist farmers and rangeland managers in accessing voluntary carbon markets that pay for carbon sequestration practices. Partner with the Contra Costa Resource Conservation District to explore implementing a program to group rangelands together for more competitive grant applications, similar to the model used by the Cachuma Resource Conservation District.

Action 1.6: Promote incentives and grants (for example, CDFA Climate Smart Agriculture programs) to improve water, fuel, and energy efficiency in agricultural operations.

Action 1.7: Support programs that incentivize replacement of older, polluting farm equipment, for example the Funding Agricultural Replacement Measures for Emission Reductions Program.

Action 1.8: Develop a program to facilitate equipment sharing for the implementation of climate-smart land management practices for small farmers that seek to implement these practices but lack access to necessary equipment such as a no-till drill seeder, tractors, mowers, etc.

MEASURE 2: Promote Conservation, Habitat Restoration, and Sustainable Management of Natural and Working Lands

Action 2.1: Develop a comprehensive conservation plan to include portions of the County not represented in the East Contra Costa County Habitat Conservation Plan and other conservation efforts, to implement natural land conservation and habitat restoration projects. Create an equitable outreach and engagement campaign during plan development and implementation.

Action 2.2: Pursue funding to implement natural land conservation restoration projects.

Action 2.3: Increase the production of high-quality, low-contamination compost locally.

Action 2.4: Develop a program to facilitate compost application on burn scars, and applicable natural and working lands, including rangelands in the county.

Action 2.5: Develop and implement a plan for the conservation of sparsely vegetated lands, such as beaches and bare rocks, that includes educating local landholders about the importance of this land type and conservation easements for private landholders on this land type.

Action 2.6: Address policy barriers that prohibit or discourage the voluntary creation or restoration and management of habitats and ecosystems by coordinating with local, State, and federal agencies.

Action 2.7: Explore the creation/expansion of tax incentives to conserve agricultural lands.

Action 2.8: Implement the recommendations in the 2015 Contra Costa County Food System Analysis and Economic Strategy to protect agricultural areas at risk of development. Maintain and enforce the Urban Limit Line, encourage infill and transit oriented development, and adopt and implement policies, programs, and projects to reduce urban sprawl and avoid land conversion.

MEASURE 3: Improve Health of Grasslands, Shrublands, and Woodlands and Mitigate Wildfire Ignition Risk and Fuel Load in the Wildland Urban Interface to Reduce Risk of Wildfire Events and Resulting GHG Emissions

Action 3.1: Engage with the East Bay Regional Parks District, local fire districts, local Fire Safe Councils, RCD, CAL FIRE, local tribal groups, and other regional, local, and state agencies to conduct fuel treatments within their jurisdictions and along highway corridors, restoring ecosystem resilience and protecting communities through updates to the Community Wildfire Protection Plan.

Action 3.2: Continue community education programs to inform residents of the importance of clearing a defensible space around homes and resources available to residents. This may include tabling at community events, information resources on the County webpage, mailers, and social media.

Action 3.3: Continue to seek funding from CAL FIRE Wildfire Prevention Grants Program to conduct fuel reduction projects, particularly in the wildland-urban interface.

Action 3.4: Implement shaded fuel breaks.

MEASURE 4: Protect the Urban Forest and Increase Urban Tree Cover

Action 4.1: Develop and adopt a County Street Tree Policy which provides guidelines for the replacement of existing trees, designates suitable trees as replacements, and enables the County to partner with community groups to seek grants to sustain and nurture the County's urban forest.

Action 4.2: Maintain and enforce the County Landscape Standards, which set specific standards for planting and maintaining trees in the County, and Tree Protection and Preservation Ordinance which provides for the protection of certain protected trees in unincorporated areas of the County and prohibits removing trees on private property without a special permit.

Action 4.3: Develop an Urban Tree Plan to actively plant and maintain trees in unincorporated communities. The plan should aim to preserve and grow the County's urban tree canopy cover, for example through establishing a shade tree requirement for new development, especially in impacted communities. Successful Urban Forest Tree Plan development and implementation will depend on community engagement.

Action 4.4: Plant new drought tolerant and fire-resistant trees at County facilities and parks following adoption of an Urban Tree Plan.

MEASURE 5: Facilitate Mechanisms to Value and Fund Local Carbon Sequestration Projects

Action 5.1: Identify costs and barriers associated with carbon offsets. Develop resources to provide assistance and increase participation from local land managers.

Action 5.2: Partner with the Contra Costa Resource Conservation District and other groups to develop and maintain an updated list of funding opportunities, resources, and application dates. Promote the California Natural Resources Agency (CNRA) Carbon Sequestration and Climate Resiliency Project Registry when it is launched in July of 2023.

Action 5.3: Establish a budget framework for investing in local carbon sequestration projects to offset the balance of communitywide emissions by 2045 in line with County targets set in the County Climate Action Plan and in support of State targets.

MOVING FORWARD

The goal is for Contra Costa County and its partners to use this study as a foundation to successfully fund and implement climate smart practices. Even though challenges exist such as needing improved equipment, regulatory barriers, cost of labor and maintenance, and land ownership, the county has a large network of individuals, community groups, non-profit organizations, and government agencies that are committed to maximizing the well-being of its residents and its natural and working lands. This strong network of dedicated individuals and the unprecedented amount of guidance and financial resources from the State puts Contra Costa in the ideal position for continued investment in maintaining resilient natural and working lands in the county.

1. INTRODUCTION

Climate change is a global phenomenon that can have harmful impacts on public health, natural resources, infrastructure, emergency response, and many other aspects of society at the local scale. ***Natural and working lands (NWL)*** have been an underutilized sector in helping to address climate change. Healthy lands can remove carbon from the air by storing it in plants and soil, reduce some of the impacts of climate change, and increase community resilience, all while providing many other benefits to wildlife, people, and the economy. In contrast, unhealthy lands can release more ***greenhouse gases (GHGs)*** than they store, increase risks from climate change, and provide fewer ecological and societal benefits. In other words, healthy lands make for healthy communities and healthy people. However, NWLs are susceptible to the impacts of climate change as well, and maintaining the existing carbon stored in California NWsL is growing increasingly more difficult due to impacts associated with wildfire and drought. Supporting the benefits provided by NWLs and mitigating the pressures placed on those lands from climate change requires strategic and effective land management. The way that lands are used and managed makes a big difference in how healthy and productive they, and the communities that rely on them, are.

Healthy Lands

Healthy Lands refer to ecosystems, landscapes, open space, natural lands, working lands, and urban environments that can ecologically function and be resilient to climate impacts.

Climate smart land management is an emerging focus for State and local climate planning. In December of 2022 the California Air Resources Board (CARB) adopted the 2022 ***Scoping Plan***, which lays out a path for the State to achieve targets for carbon neutrality and reduce anthropogenic GHG emissions by 85 percent below 1990 levels no later than 2045. The Scoping Plan NWL modeling finds that due to climate change impacts from drought, heat, and wildfire, the State's NWLs, especially ***forests*** and shrublands, will likely emit more GHGs than they store in the future. The Scoping Plan calls for the accelerated use of nature-based solutions to help achieve the State's climate change goals by minimizing losses of carbon from NWLs especially those due to wildfire, increasing carbon storage in NWLs where possible, and supporting other policy priorities such as improved public health and safety and secure food and water supplies.

Climate Smart Land Management

Managing lands to deliver climate benefits is known as climate smart land management. Specific actions or practices may be called climate smart practices, and, in the case of agricultural practices, may be referred to as climate smart agriculture.

THE PURPOSE OF THIS STUDY

This Healthy Lands, Healthy People: Carbon Sequestration Feasibility Study for the County of Contra Costa aims to provide the foundation for implementing nature-based solutions and climate smart strategies on the NWLs in the county to support the achievement of State goals outlined in the Scoping Plan and other key planning documents and aid farmers, land managers, and urban gardeners in obtaining funding and resources needed to successfully implement practices, while increasing the resilience of both the lands and the communities that enjoy and rely on them.

This report:

1. Provides background about the carbon cycle and carbon sequestration
2. Provides regional context including: expected climate change impacts, land use planning, and trends in land-based carbon in Contra Costa County
3. Highlights climate smart land management practices that can be applied to the natural and working landscapes in Contra Costa County
4. Identifies Measures and Actions to support implementation of climate smart land management.
5. Explores some of the emerging science and policy areas for NWLs management
6. Outlines opportunities for grant funding and other resources

What are Natural and Working Lands in Contra Costa?

CROPLANDS

Croplands include cultivated field crops, vineyards, and orchards

URBAN FARM AND FORESTS

Urban farms and forests are found in developed areas.

NATURAL LANDS

Natural lands, rangelands, and pastures are forests, woodlands, grasslands, shrub/scrub, and pastures.

For more information, watch this video developed by the UC Cooperative Extension that describes how Contra County's Healthy Lands, Healthy People initiative implements this statewide vision. It describes the outreach and education efforts made on behalf of sustainable practices for rangeland, cropland, and urban agriculture; and presents links to California State programs and incentives in which agricultural operators may choose to participate.

THE CARBON CYCLE, CLIMATE CHANGE, AND LAND MANAGEMENT

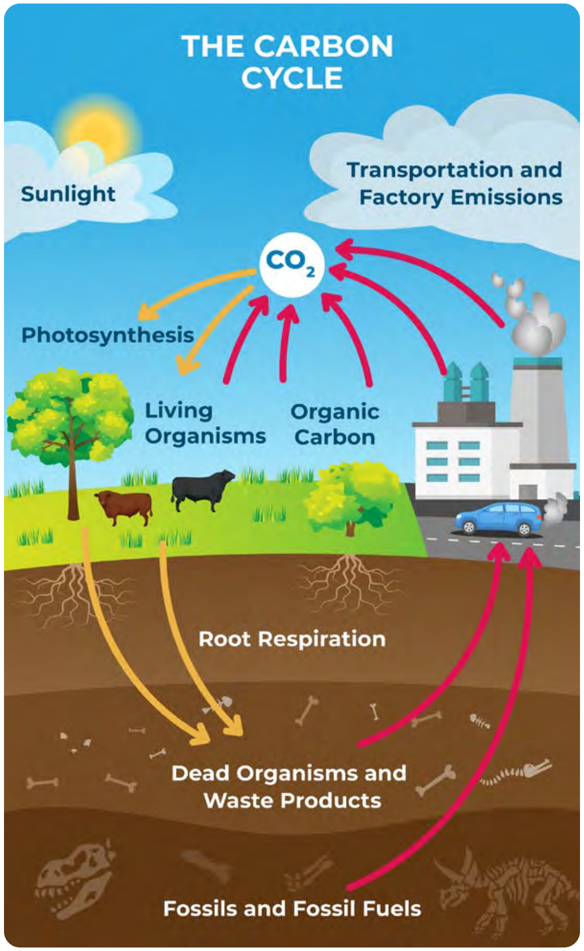
Carbon is the foundation for all life on earth and is found in the atmosphere, rocks and sediments, ocean, and all living things. The carbon cycle is the process in which carbon is exchanged or cycled between the atmosphere and the other parts of the earth system including the biosphere (plants, animals, and other life forms), hydrosphere (water bodies), pedosphere (soils), and lithosphere (Earth's crust and mantles, including rocks and fossil fuels).[1] Because our planet and its atmosphere form a closed environment, the total amount of carbon in the system does not change. However, where the carbon is located, how much is in the atmosphere versus other parts of the earth system, is constantly in flux. ***FIGURE 1*** depicts the carbon cycle.

During photosynthesis, plants and algae take carbon from the atmosphere and store it in their biomass. Soils are made in part of partially decomposed plant matter, meaning that they contain a lot of carbon that those plants took in from the atmosphere while they were alive. Soil organic carbon (SOC) is a primary indicator of soil health and functioning. Carbon can be released into the atmosphere through a variety of mechanisms including plant respiration, decomposition, soil disturbance, volcanic eruption, fire, or fossil fuels combustion to name a few. Human activities and natural factors determine whether there will be more carbon lost or stored in natural and working lands in any given year.

In the atmosphere, carbon in the form of carbon dioxide (CO_2) is a GHG that traps heat. CO_2 is naturally occurring, and having some GHGs in the atmosphere is essential for creating warm enough temperatures on earth to support life. However, human activities are creating an imbalance in this natural process, vastly increasing the amount of carbon in the atmosphere and driving climate change. Increasingly, this pattern becomes a feedback loop where the impacts from climate change, especially increases in frequency and size of wildfires, are themselves tipping the scale further to create additional losses of carbon from lands into the atmosphere.

Human management activities have a crucial role to play in minimizing losses of carbon stored in NWLs soils and vegetation. Land management has impacted carbon stocks in California lands for centuries. For example, indigenous peoples have used controlled fire and other techniques to promote ecological diversity, reduce risk of catastrophic wildfires, and maintain ecosystem health.[2] Some management practices, such as clearcutting or tilling, can disturb soils and vegetation causing the release of stored carbon into the atmosphere.[3] Alternatively, a variety of climate smart land management activities implemented now, can help to increase the health of soils and NWLs. Healthy lands sequester more carbon, hold more water in the soil, are more productive for farming and grazing, and are more resilient to climate impacts.

FIGURE 1. The Carbon Cycle



1. *California Air Resources Board. 2018. An Inventory of Ecosystem Carbon in California's Natural & Working Lands.* ***https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf***.
2. ***https://www.nps.gov/subjects/fire/indigenous-fire-practices-shape-our-land.htm***
3. *California Natural Resources Agency (CNRA). April 22, 2022. Natural and Working Lands Climate Smart Strategy.* ***https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Expanding-Nature-Based-Solutions/CNRA-Report-2022---Final_Accessible_Compressed.pdf***

HEALTHY SOILS AND BIOLOGICAL CARBON SEQUESTRATION

Biological carbon sequestration is the process whereby living organisms remove carbon from the atmosphere and store or "sequester" it in the biomass of the micro-organisms and vegetation in landscapes, such as forest, soils, and oceans. Plants also release carbon, in the form of carbohydrates and other molecules (collectively called exudates), into the soil through their roots, where they increase SOC[4] and support a diversity of soil microbes and fungi[5] that facilitate soil carbon sequestration. Carbon must filter through soil microbes to create stabilized forms of carbon that will remain in the soil for a longer period before returning to the atmosphere than if the soil lacked adequate microbial activity.[6] Biological carbon sequestration and soil carbon stabilization processes can occur on different timelines, taking anywhere from a few hours to a few years.[7] Given that soil disturbance activates decomposition of organic matter by fungi and other microbes, and therefore, increases carbon release from soil, practices that protect soil and improve soil health is essential.

Healthy soils have higher SOCs, which in turn decreases soil erodibility, improves soil water holding capacity, and increases productivity.[8] These benefits are good for both the environment and for farmers, making climate smart agriculture practices a key component of a comprehensive NWLs strategy, and provides the rationale for the California Department of Food and Agriculture (CDFA) Healthy Soils Program. The Healthy Soils Program stems from the California Healthy Soils Initiative, a collaboration of State agencies and departments to promote the development of healthy soils on California's farmlands and ranchlands and provides financial assistance for implementation of conservation management that improve soil health, sequester carbon and reduce GHG emissions.[9]

4. *Poonam Panchal, Catherine Preece, Josep Peñuelas, Jitender Giri. Soil carbon sequestration by root exudates. Trends in Plant Science, Volume 27, Issue 8, 2022. Pages 749–757. ISSN 1360-1385.* **https://www.sciencedirect.com/science/article/pii/S1360138522001303**
5. *Badri DV, Vivanco JM. Regulation and function of root exudates. Plant Cell Environ. 2009 Jun;32(6):666-81. doi: 10.1111/j.1365-3040.2008.01926.x. PMID: 19143988.*
6. *Kerlin, Kat. Compost Key to Sequestering Carbon in the Soil. August 14, 2019.* **https://www.ucdavis.edu/climate/news/compost-key-sequestering-carbon-soil**
7. *California Natural Resources Agency. April 22, 2022. Natural and Working Lands Climate Smart Strategy.* **https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Expanding-Nature-Based-Solutions/CNRA-Report-2022---Final_Accessible_Compressed.pdf**
8. *Flint, L., Flint, A., Stern, M., Mayer, A., Vergara, S., Silver, W., Casey, F., Franco, F., Byrd, K., Sleeter, B., Alvarez, P., Creque, J., Estrada, T., Cameron, D. (U.S. Geological Survey). 2018. Increasing Soil Organic Carbon to Mitigate Greenhouse Gases and Increase Climate Resiliency for California. California's Fourth Climate Change Assessment, California Natural Resources Agency. Publication number: CCCA4-CNRA-2018-006*
9. **https://www.cdfa.ca.gov/oefi/healthysoils/**

HEALTHY LANDS, HEALTHY PEOPLE

The diverse landscapes and biodiversity found throughout California's NWLs provide a multitude of benefits to the people of California, including clean water, clean air, biodiversity, food, economic prosperity, recreational opportunities, continuation of traditional tribal ways of life, mental health benefits, and many others. At the regional scale, changing land conditions through climate change, disturbance or active management can generate GHG emissions and accentuate warming and affect the intensity, frequency, and duration of extreme events, including extreme heat and precipitation that can both negatively impact public health, infrastructure, and property.[10] Water stress, heat, and other climate-related disturbances can reduce agricultural productivity, impacting the livelihoods of agricultural workers and reducing the resilience of the food supply. By contrast, practices that increase soil carbon and foster healthy soils can increase the resiliency of agricultural lands. Reducing and reversing land degradation, at scales from individual farms to entire watersheds, can provide cost-effective, immediate, and long-term benefits to communities. Healthier lands better filter pollutants from the air that cause health issues in people, can decrease ambient temperatures during heatwaves, thereby reducing health impacts from heat, and access to green spaces can improve mental health. Implementing climate smart practices in NWLs can result in reduced all-cause mortality and hospitalizations and emergency room visits due to respiratory diseases and cardiovascular issues. These and other co-benefits are discussed at greater length in Section 4.4. The bottom line is that investments in the health of our natural and working landscapes is an investment in the health of the communities and people of Contra Costa County.

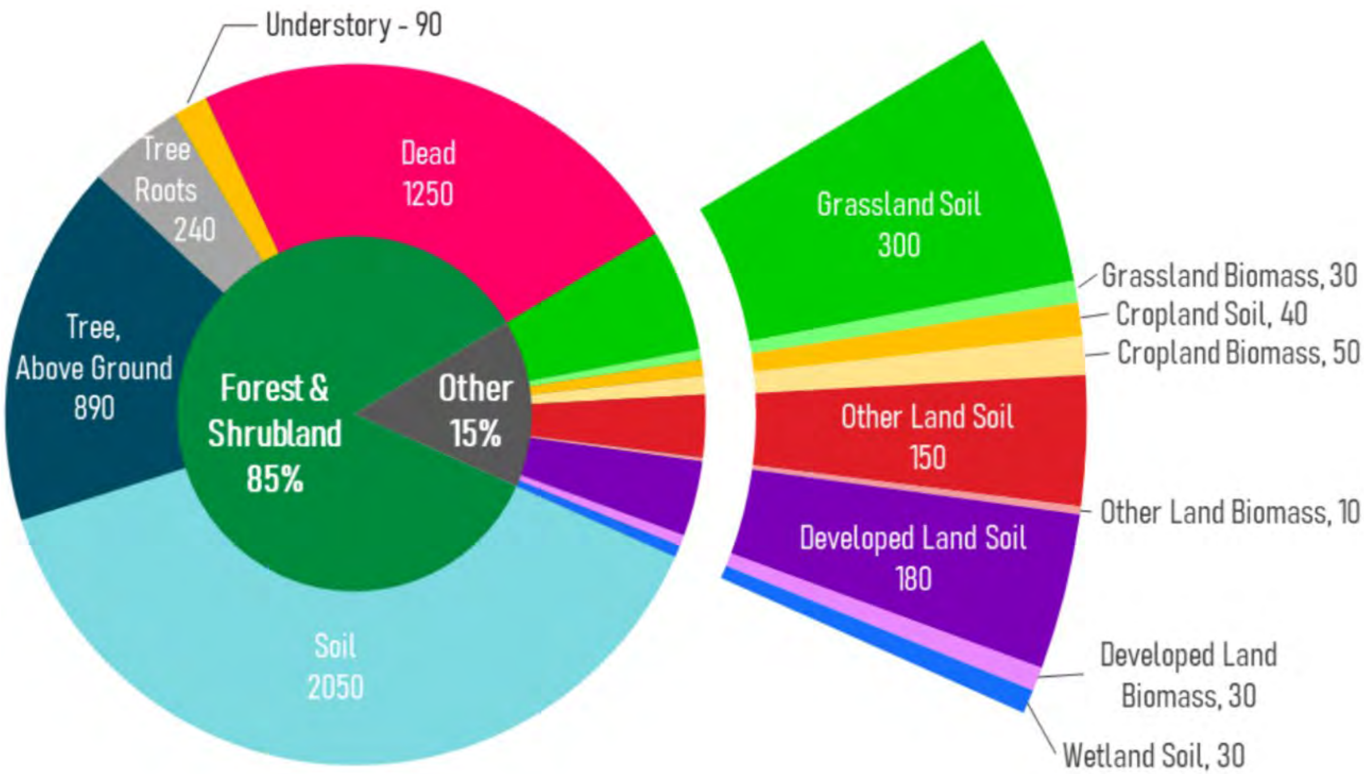
10. IPCC WGIII Special Report on Land and Climate

NATURAL AND WORKING LANDS CARBON STOCK AND STATE GOALS

Carbon Stocks in California Natural and Working Lands

CARB's 2018 ecosystem carbon inventory shows there are approximately 5,340 million metric tons (MMT) of carbon in California's NWLs.[11] Forests and shrublands contain most of California's carbon stock, because they cover the majority of California's landscape and have the highest carbon density of any ***land cover*** type. All other land categories combined comprise over 35 percent of California's total acreage, but only 15 percent of carbon stocks. Roughly half of the 5,340 MMT of carbon resides in soils and half in plant biomass. See ***FIGURE 2*** for a breakdown of how carbon stocks in California's NWLs are distributed amongst land cover types.

FIGURE 2. Carbon Stocks in NWLs



Source: California Air Resources Board. 2022 Scoping Plan.

11. *California Air Resources Board. 2018. An Inventory of Ecosystem Carbon in California's Natural & Working Lands.* **https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf**. *Accessed October 27, 2021.*

Carbon Neutrality

For the first time, the 2022 CARB Scoping Plan includes the quantification of NWLs and related GHG emissions and sequestration in order to meet carbon neutrality goals. In the past, the focus was restricted to reducing emissions of GHGs from other sectors, including energy, transportation, and industrial. Carbon neutrality occurs when there is a state of net-zero carbon emissions, achieved by balancing total CO_2 emissions with equal removal of atmospheric carbon. In other words, when sources of carbon emissions released into the atmosphere are balanced by parts of the earth system that remove carbon from the atmosphere – known as carbon sinks. NWLs can function as both a carbon source and a carbon sink. Their ability to act as a carbon sink, by sequestering carbon from the atmosphere and storing it in vegetation and soils, means that NWLs will play an increasingly important role in pursuing State carbon-neutrality goals. Land cover modeling completed by the State, as part of the Scoping Plan, found that due to increasingly frequent and catastrophic wildfires and intense droughts among other climate impacts, California's lands will be a net source of GHG emissions when accounting for both carbon sequestration and GHG emissions from lands. This expected trend is driven largely by increased stress and mortality in forests and shrublands turning them from carbon sinks into sources of carbon emissions. Some landscapes including urban forests and grasslands are projected to help sequester carbon and reduce the net amount of GHG emissions due to implementation of management strategies in the 2022 Scoping Plan. These modeling results further emphasize the need for strategic land management to help mitigate the impacts from climate change. CARB's general recommended approach is to restore carbon in places where it has been lost and reduce large carbon losses on NWLs through active, attentive, and adaptive management.

Natural and Working Lands Goals

CARB has established a statewide target of minimizing losses of carbon stock in NWLs to a decrease of only 4 percent. CARB has identified a set of actions to accelerate adoption of climate smart practices to support achieving this target listed below:

- Increasing climate smart forest, shrubland, and grassland management to at least 2.3 million acres per year—an approximate 10x increase in management from current levels
- Increasing climate smart agricultural practices by at least 78,000 acres adopted per year, annually conserving at least 8,000 acres a year of croplands, and increasing organic agriculture to comprise at least 20 percent of cultivated acres in California by 2045—an approximate 7.5x increase in healthy soils practices from previous levels and a 2x increase in total acres of organic agriculture
- Increasing annual investment in urban trees in developed lands by at least 200 percent above historic levels and establishing defensible space on all parcels by 2045
- Restoring at least 60,000 acres, or approximately 15 percent of all Sacramento–San Joaquin River Delta (Delta) wetlands, by 2045
- Reducing land conversion of deserts and sparsely vegetated landscapes by at least 50 percent annually from current levels, starting in 2025.

Opportunity Beyond the CARB Natural and Working Lands Goals

CARB acknowledges that even if the carbon stock target above is met, and the management actions above are implemented, the modeling for NWLs indicates that California's lands will be a net source of emissions. Additional climate smart management practices and additional landscapes, such as those included in the Climate Smart Strategy, have the potential to increase carbon stocks and reduce GHG emissions from NWLs beyond the levels modeled for the State's Scoping Plan.

Contra Costa County Approach

The County of Contra Costa is taking a proactive approach in land management, reducing GHG emissions and increasing sustainability in the county through numerous concerted planning efforts and strategic partnerships, including the simultaneous update of the County General Plan and Climate Action Plan (CAP) and production of this study. Through the measures and actions identified in these planning efforts and coordination with jurisdictions and organizations in the county, the County hopes to contribute to the achievement of the State's carbon neutrality and CARB's NWLs targets through climate action and wildfire risk mitigation, protecting existing carbon stocks through conservation, and increasing carbon stocks where possible through significant sequestration. There are many census tracts within the county that can significantly increase their urban forest cover to reap equity, health, and climate benefits.[12] While grasslands only make up 9 percent of land cover in California, modeled land cover data provided by ***LANDFIRE*** shows grasslands make up approximately 30 percent of the land cover in the county. Therefore, there is ample opportunity for Contra Costa County to increase carbon stored in urban forest and grasslands, the two landscapes projected to increase in carbon stocks given active management in the Scoping Plan models, while encouraging actions that reduce risk of generating GHG emissions from other land cover types. By undertaking this analysis and outlining the potential for the myriad climate, social, and economic benefits of implementing climate smart practices on NWLs across the county, Contra Costa County hopes to provide the foundation for successful funding of climate smart project implementation through grants and other mechanisms.

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12. Tree Equity Score Map showing Contra Costa County. **https://treeequityscore.org/map/#10.7/37.8908/-121.9629**

2.

WHAT'S HAPPENING IN THE REGION?

CONTRA COSTA COUNTY

Contra Costa County is located in the East Bay area of Central California. Although adjacent to major metropolitan areas, including San Francisco and Oakland, over 50 percent of the county's approximately 802 square miles of land is dedicated to non-urban uses, such as agriculture, wetlands, parks, recreation, and general open space. In the west and central county, the primary land uses in suburban cities and towns are residential, commercial, and industrial. In the east county, land has primarily been designated for agriculture, conservation, parks, and general open space. Over time, development pressure has steadily moved eastward from the communities bordering the bay in the west to the valleys near Mount Diablo, and eventually to the communities in the east county sub-area.

CLIMATE CHANGE IN THE COUNTY

Climate change is expected to have significant adverse impacts locally, throughout California, and worldwide, unless considerable steps are taken to reduce GHG emissions. In order to assess the future impacts of climate change expected in the region, Contra Costa County prepared a Vulnerability Assessment[13] as part of Envision Contra Costa 2040. The climate hazards identified in the Vulnerability Assessment are listed in ***FIGURE 3***. Though climate change impacts may be widespread, and affect numerous vulnerable populations and resources, those listed ***FIGURE 4*** primarily address impacts to NWLs.

13. *Contra Costa County. Vulnerability Assessment.* ***https://cocogis.maps.arcgis.com/apps/MapSeries/index.html?appid=869e23fd058d48dbb1e514ef15841831***

FIGURE 3. Climate Change Impacts to NWLs in Contra Costa County

Agricultural Pests and Diseases

- Inhibited plant growth
- Product defects
- Crop and revenue losses
- Decreased overall land health

Air Quality

- Increased temperatures
- Crop contamination

Bay Shoreline Flooding

- More severe flooding of susceptible NWLs
- Surging tides during storm events
- Inundation/saltwater intrusion of NWLs

Drought

- Limited water availability for agricultural uses and ecosystems
- Decreasing crop/livestock capacity on farms
- Low riverine and lake levels

Extreme Heat

- Harm to vegetation and animals
- Cascading impacts to infrastructure, including utilities and roadways
- Exacerbated drought conditions

Flooding

- Damage to habitats and infrastructure
- Crop and revenue losses
- Nutrient leaching from working lands

Fog Reduction

- Agriculture and tree growth rely on cool air and moisture provided by summer fog
- Decreasing fog may lead to increased air pollutants

Landslides/ Debris Flow

- Disturbance of natural ecosystems
- Damage to crops or croplands
- Cascading impacts to infrastructure, including utilities and roadways

Severe Storms

- Hail can cause damage to plants and buildings
- Lightening and/or strong winds can trigger wildfires
- Downed powerlines can interrupt services

Sea Level Rise

- May cause permanent flooding in low-lying areas
- Threats to portions of prime agricultural land
- Saltwater intrusion can disrupt freshwater supplies

Wildfire

- Can destroy ecosystems and cause long-term changes to landscapes
- Damage to croplands; crop and revenue losses
- Wildfire smoke can render crops unsalable

Source: Envision Contra Costa 2040 Climate Change Vulnerability Assessment. ***https://cocogis.maps.arcgis.com/apps/MapSeries/index.html?appid=869e23fd058d48dbb1e514ef15841831***

RELEVANT EXISTING COUNTY PLANNING RESOURCES

The following section describes key policy and planning documents that drive carbon sequestration related efforts in Contra Costa County. The CAP and General Plan are currently being updated as part of Envision Contra Costa 2040. The sections below describe the existing status of these documents and how they relate to NWL in the county.

Climate Action Plan

In December 2015, the County adopted a CAP. The objective of the CAP is to detail how the County can achieve long-term GHG emissions reduction goals for the year 2035. Additionally, the plan includes actions to improve public health, enhance quality of life, and support goals identified in the County's General Plan and other policy documents. The CAP identifies strategies regarding energy use, transportation, land use, water use, and solid waste to reduce communitywide GHG emissions and proposes an approach to addressing near-term climate change while increasing the county's resilience.

The Contra Costa County 2015 CAP provides insights for this feasibility study primarily relative to the agricultural sector. In both 2005 and 2013, agricultural GHG emissions accounted for about 4 percent of the total GHG emissions in the county. The CAP GHG forecast scenario predicts no change to the emissions of the agricultural sector through the year 2035. The CAP includes a measure regarding agricultural land uses that increases opportunities to grow, sell, and purchase local food through the following action items:

1. **Continue to support local farmers markets, local community gardens, school gardens, and other urban agricultural practices, including in areas with poor food access**
2. **Amend the Zoning Code to allow urban agriculture in appropriate areas**
3. **Amend the General Plan to add a policy that encourages community gardens in new residential developments as appropriate**
4. **Encourage partnerships between local food growers and local food retailers**
5. **Encourage partnerships between local food growers and local institutions such as schools, hospitals, colleges, and correctional facilities**
6. **Continue to discourage schools being sited in agricultural areas**
7. **Encourage retention of agricultural land to maintain the county's agricultural base and enable long-term carbon sequestration**

General Plan and Land Use

As stated above, the County is in the process of updating its General Plan. The current General Plan was adopted in 1991. The new General Plan, along with the updated CAP, is anticipated to be adopted in 2024 and will include the following elements:

- Land Use
- Public Facilities and Services
- Stronger Communities
- Health and Safety
- Transportation
- Conservation, Open Space, and Working Lands
- Growth Management
- Housing

Four themes will run throughout the 2024 General Plan: economic development, sustainability, environmental justice, and community health.

These goals and policies, together with implementation measures guide the County's decisions for future growth, development, and resource conservation.

Contra Costa has an Urban Limit Line (ULL) that was established by county voters through the adoption of Measure C in 1990 and renewed with the passage of Measure L in 2006. The purpose of the ULL is to ensure the preservation of identified non-urban agricultural, open space, and other areas by establishing a line beyond which no urban land uses can be designated. The Land Use element also details the 65/35 Land Preservation Standard, which is an additional component of the ULL. This standard limits urban development to no more than 35 percent of county lands, ensuring 65 percent or more of land use be designated for agriculture, open space, wetlands, parks, and other non-urban uses. The ULL essentially functions as a conservation measure, strongly constraining development of NWLs outside the ULL boundaries. Rural ranchettes may be developed outside the ULL, potentially leading to conversion of natural lands. Additionally, conversion of natural and agricultural lands within city boundaries may be at risk for conversion to other land uses (from natural to agricultural uses, or from natural and agricultural to developed) if those jurisdictions do not have limits and policies in place to prevent conversion and promote conservation.

Local Agriculture Report

The Contra Costa County Department of Agriculture is responsible for enforcing regulation in the local agricultural industry. Their annual crop reports depict the array of agricultural commodities being grown in the region. In 2018, livestock production had the second highest gross value of all industries, with cattle and calves bringing in the most income of any individual agricultural product in the county. This finding highlights the importance of increasing the use of climate smart strategies in rangelands (grasslands, shrublands, and oak woodlands) in the county. Rangeland productivity is already, and will continue to be, negatively impacted by climate change in large part due to reductions in forage productivity and quality, which in turn impacts herd productivity and health.[14] Adoption of climate smart strategies, particularly those that increase soil carbon, can increase the resilience of rangelands.[15]

14. *Balachowski, et.al. United States Department of Agriculture California Hub. Climate Vulnerability Assessment of California Rangelands. June 2018.* ***https://www.climatehubs.usda.gov/sites/default/files/california_rangelandsva.pdf***
15. *Flint et al. California's Fourth Climate Change Assessment Technical Reports on Agriculture. Increasing Soil Organic Carbon to Mitigate Greenhouse Gases and Increase Climate Resiliency for California. August 2018.* ***https://climateassessment.ca.gov/techreports/agriculture.html***

OPPORTUNITIES AND CHALLENGES FOR TAKING CLIMATE SMART ACTION

Successful climate smart land management will often require trusted partnerships given the complexity of land ownership in California and the importance of meaningful community engagement. In recognition of this, numerous community engagement efforts were undertaken as part of this study, including a survey and seven focus groups conducted by the UC Cooperative Extension. These engagement efforts resulted in feedback that helped identify both challenges and opportunities for implementing climate smart land management practices summarized in ***FIGURE 4***. See ***Appendix B*** for the full Sustainable Agricultural Lands Conservation (SALC) Focus Group Report and select survey responses.

Identified Challenges

The survey of over 120 farmers and rangeland managers represented three different categories of agricultural land management. The categories consisted of urban agriculture (typically small, multi-crop farms in developed areas), cropland (row crops, orchard, vineyard), and rangelands (non-irrigated grasslands used for grazing livestock, mostly cattle). Identified challenges to adoption of climate smart agriculture practices comprise several types of barriers including those related to:

- Cost
- Operational/logistical barriers
- Policy/governance
- Lack of information
- Lack of interest
- Access to resources
- Concerns over downstream consequences
- Maintenance requirements

Discussions with the Urban Agriculture and Built Environment, School Gardens, and Faith-Based Landscapes focus groups highlighted various obstacles more related to increasing carbon sequestration through urban greening projects and urban agriculture on developed lands. Types of barriers indicated for these land uses included:

- Lack of legal access to land
- Local policy constraints
- Lack of resources for maintenance
- Lack of access to local decisions on land use and lack of support from local decision-makers
- Concerns about downstream effects

Ownership and Jurisdiction over NWLs

Land is owned and managed in numerous ways and subject to different sets of restrictions based on the jurisdiction where it is located. About 40 percent of the county is under the jurisdiction of 19 incorporated cities and towns, and large portions of the remaining unincorporated area are part of public park systems, like Marsh Creek State Park, Mount Diablo State Park, and the East Bay Regional Park District, as well as the East Contra Costa Habitat Conservancy, and water districts, including East Bay Municipal Water District and Contra Costa Water District. Requirements, opportunities, and challenges for implementation of climate smart land management practices will differ for public versus private lands, and land use policy will vary between different incorporated cities and the County. Coordination will be essential in furthering the adoption of carbon sequestration practices at a large scale.

Identified Opportunities

Opportunities to increase adoption of climate smart agriculture practices identified in the surveys center around overcoming the identified barriers. This may be achieved through:

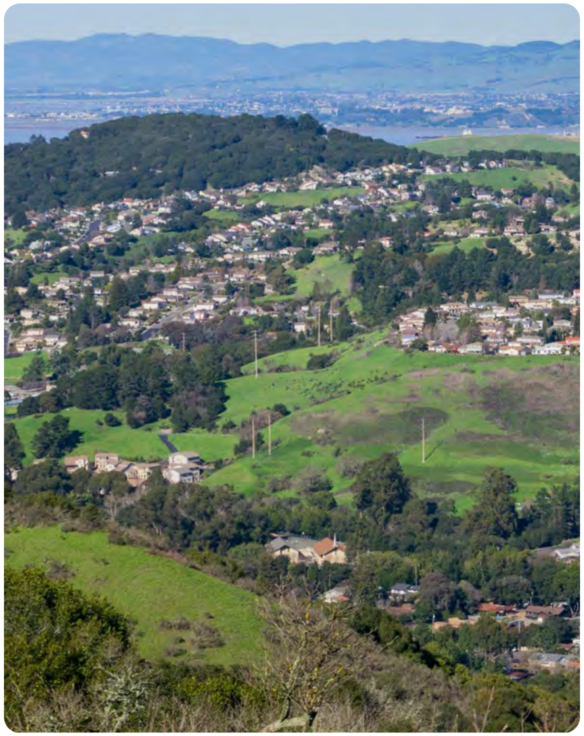
- Increased access to financial resources and incentives
- Consultation or programs that help overcome operational or logistical barriers
- Dissemination of additional information and guidance on specific practices
- Promoting the increased use of practices already being implemented.
- Continued outreach to farmers and ranchers not currently engaged

The Farmer and Rancher-Led Climate Solutions Report provides recommendations for engaging and empowering farmers not currently engaged in implementing climate smart land practices by addressing their particular needs and concerns, including through promotion of national and State programs providing incentives, workshops, and rancher-to-rancher programs among other strategies.[16] Agricultural lands are already heavily managed, and there is enormous potential for increasing carbon stocks in agricultural soils. Farmers and ranchers stand to bear negative impacts from climate change, including reduced productivity of crops and livestock. They can also benefit from implementation of practices that increase soil health and resilience to climate impacts. Furthermore, the agricultural community has shown willingness to adapt and adopt new practices when presented with clear evidence of benefits and assistance in overcoming barriers. Thus, farmers and ranchers are key allies in increasing adoption of climate smart practices, and it is important to prioritize supporting the agricultural community in this effort.

Opportunities for increasing climate smart management of urban areas also includes overcoming barriers. This may be accomplished through:

- Securing access to land for urban greening and urban agricultural uses
- Removing policy barriers and/or streamlining permitting requirements
- Providing guidance about climate smart practices
- Coordination between jurisdictions, community groups, property owners, businesses, and agencies
- A program to organize and share resources among disparate community gardens; this program could be sponsored by UC Cooperative Extension, the County, or another entity
- Partner with existing programs for long-term maintenance of these green spaces, such as Climate Corps, Civic Spark, Civicorps, and Food Corps for workforce development at stewarded gardens, campuses, and apartment complexes that host urban agriculture or community gardens
- Assistance accessing resources and funding

- Some suggestions from focus group participants for opportunities to expand land available for urban agriculture included the following:
- Dialoguing with owners of multifamily residences about whether they could cultivate green spaces or community gardens on apartment properties
- Identifying and restoring creek-side and open space properties that are underutilized
- In downtown settings, developing rooftop gardens



16. *Farmer and Rancher-Led Climate Change Solutions Report. November 2021.* ***https://www.cdfa.ca.gov/oefi/climate/solutions_report.html***

Summary of Key Findings from Community Engagement by Land Use

FIGURE 4. Summary of Challenges and Opportunities Identified through Engagement

All Working Lands

CHALLENGES:

- There is very little interest in improving the fuel efficiency of farm equipment.
- There is a small but significant portion of respondents not interested in implementing any of the climate smart practices listed in the survey.

OPPORTUNITIES:

- Many land managers and farmers are already practicing some of the climate smart practices at some level or are interested in adopting them.
- Climate smart practices and ecosystem benefits are generally seen as beneficial to farm productivity.
- There seems to be a general willingness to increase adoption of practices if barriers are removed.

Croplands-Specific

CHALLENGES:

- Legal access, operational/logistical barriers, cost, and policy were all identified as obstacles to forested riparian habitat restoration.
- The need for additional information and operational/logistical barriers were the primary obstacles identified for implementing windbreaks and hedgerows.
- The main barrier for the other practices listed in the survey was primarily the need for additional information.

OPPORTUNITIES:

- Adoption rates for some practices may increase if additional information or consultation is provided, in particular for fertilizer management.

Natural Lands and Rangelands-Specific

CHALLENGES:

- Survey responses around practice adoption and interest indicated a fairly even divide in the approaches to rangeland management and perhaps a larger limit on adoption rate for climate smart practices on rangelands than for croplands.
- Cost of implementation and labor were viewed as major barriers for implementation of rangeland practices.
- Tools and equipment requirements were seen as a minor to substantial barrier for practice implementation.
- The need for additional information was viewed as a minor to mild barrier.

OPPORTUNITIES:

- Some rangeland managers are already applying some carbon sequestration practices.
- Rangeland respondents all agreed that habitat conservation and watershed management improve desired outcomes, while fuel management was mostly viewed as beneficial but is seen by some as conflicting with or unrelated to desired outcomes.
- Financial support and incentives could increase practice adoption.
- Equipment sharing programs may be helpful in reducing barriers for rangeland managers.
- Providing additional information and consultation support may help to increase the acceptability of, or interest in, climate smart practices.

Urban Lands

CHALLENGES:

- Cities often have rules about what can or cannot be planted (for instance, fruit trees are sometimes seen as creating a mess that attracts rodents).
- Concerns about herbicide, fertilizer, and pesticide use at public facilities such as school gardens
- Some small community groups do not have resources available to maintain non-native trees that were planted previously, nor labor-power or funds to replace them.
- Burdensome daily care requirements.
- Water and energy costs for some urban greening projects.
- Concerns about fire hazard when using straw and wood chips as mulch.
- Lack of clarity or inclusion of climate smart practices in the job descriptions and/or responsibilities of grounds management staff.
- Without urban or carbon land trusts, there is the problem of insecure land tenure and reluctance to devote time and effort to cultivating land that can be taken away.

OPPORTUNITIES:

- General recognition of co-benefits associated with urban greening and urban agriculture practices.
- Discussions included the aspiration that every urban farm, community garden, faith-based, or therapeutic site include myriad features that could increase carbon sequestration, provide numerous co-benefits, and enhance their roles as local neighborhood resource centers.

3.

NATURAL AND WORKING LANDS LAND COVER AND CARBON STOCK ANALYSES

WHAT IS A LAND-BASED CARBON INVENTORY?

Efforts to conserve, restore, and manage NWLs effectively require an understanding of the current land-based carbon stock and carbon sequestration potential of land management activities therein. This understanding is gained by assessing a baseline of carbon stocks and using that assessment for future comparisons and tracking of carbon sequestration and GHG-emission reduction projects. Land-based carbon inventories are assessments estimating the quantity of carbon stored in the different ***land cover*** types described below. Inventories provide a snapshot of the carbon stock in a region's land-based ecosystems at a given moment in time. Using multiple inventories can help identify trends in land cover change and estimate increases or decreases in carbon stocks between the inventory years analyzed. Contra Costa County conducted a countywide land-based carbon inventory for 2021 for this project to provide the basis for estimating carbon stocks in Contra Costa County lands.[17]

17 *A historical county-wide carbon stock inventory was also conducted but not included in this final report. For results and discussion of the historical carbon stock inventory, see* ***Appendix C****,* ***Appendix D****, and* ***Appendix E****.*

Land Cover Classes

Land cover describes what is physically present at a location. The land cover classifications used in this report are based on the National Land Cover Database and are described below:

CULTIVATED AND FIELD CROPS: areas used to produce annual crops, such as corn, tomatoes, or other vegetables.

ORCHARDS: areas used to grow perennial woody tree crops, such as cherries, almonds, etc.

PASTURE AND HAY: areas of grasses and/or legumes planted for livestock grazing, or the production of seed or hay crops, typically perennial plants.

FOREST: areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover.

SHRUB/SCRUB LANDS: areas dominated by shrubs, less than 5 meters tall, with shrub canopy typically greater than 20% of total vegetation.

GRASSLAND/HERBACEOUS: areas dominated by grassy or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management, such as tilling, but can be utilized for livestock grazing.

VINEYARDS: areas used to grow perennial woody vine crops such as grapes.

WETLANDS: areas where the soil or substrate is periodically saturated or covered with water.

DEVELOPMENT: areas with developed with impervious surfaces and features generally associated with towns or cities including residential, commercial, and industrial uses.

OPEN WATER: areas of open water such as lakes, reservoirs, rivers, and oceans, generally with less than 25% cover of vegetation or soil.

BARREN: areas with very little vegetative cover and accumulations of earthen material such as bedrock, beaches, desert, sand dunes, strip mines, gravel pits, and so on.

HOW CARBON STOCKS ARE CALCULATED

This section provides an overview of how carbon stocks are calculated. For the full methodology and results of the baseline scenario analysis, please see ***Appendix C*** and ***Appendix D***. Land-based inventories provide estimates of carbon stocks, stock changes, and resulting GHGs sequestered or emitted from different stock changes. The CARB inventory found that NWLs were a source of GHG emissions from 2001 to 2011, releasing more carbon than they stored. In 2012 to 2014, they returned to being a slight carbon sink, storing more carbon than they released.[18] Carbon stock estimates are based on the sum of carbon stored in different carbon pools. Carbon stock analysis includes carbon stored in the following carbon pools:

- Above- and below-ground live biomass
- Above- and below-ground dead standing trees
- Downed dead wood (trees, branches, and logs on the ground surface)
- Litter (e.g., freshly fallen or slightly decomposed leaves, bark, twigs, flowers, fruits, and other vegetable matter)
- Soil (e.g., soil microbial communities, soil aggregates, mineralized carbon)

Carbon stored in all above- and below-ground biomass (including live, dead, and litter), is calculated using volumetric estimates of carbon mass (metric tons per hectare) provided by CARB.[19] These estimates will be provided for every combination of Existing Vegetation Type, Height, and Cover and assigned to each 30-by-30-meter cell in the county. The carbon values are then summed within each land-cover class. See ***Appendix C***, ***Appendix D***, and ***Appendix E*** for more details.

Uncertainties and Limitations

Many factors will influence potential future trends in carbon stocks, including both anticipated and unforeseen impacts from climate change and policy implementation. Furthermore, continued improvements in the science and protocols for tracking and estimating carbon stocks in land will mean that future estimations may be further refined and include additional sets of assumptions or data than were available and considered best practice at the time this analysis was conducted.

In Contra Costa County, the largest soil carbon per acre is stored in lands bordering the Delta. The Delta borders the northern and eastern edges of the county. The soils in the Delta are some of the richest in the world, because they are composed of organic material from decaying plants that accumulated over millennia.[20] Therefore, protection of Delta soil is a priority for Contra Costa County.

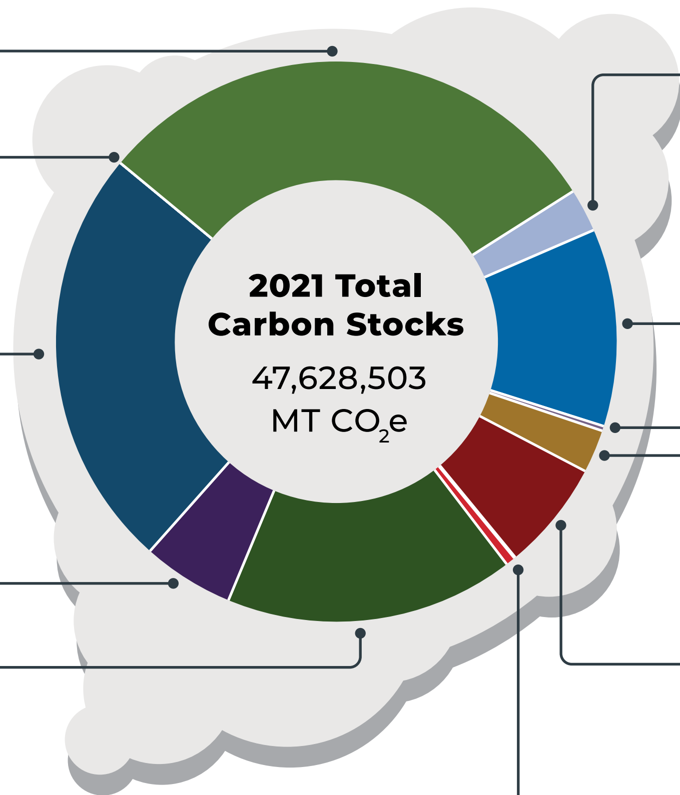
18. *California Air Resources Board. 2017. California's 2017 Climate Change Scoping Plan.* **https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp_1.pdf**
19. *Volumetric estimates of carbon mass were provided by Klaus I. Scott, Emission Inventory Analysis Section of the Greenhouse Gas & Toxics Emission Inventory Branch, AQPS Division at CARB on November 17, 2020*
20. *The New Humanitarian. 2017. California's Delta Poised to Become Massive Carbon Bank.* **https://deeply.thenewhumanitarian.org/water/community/2017/06/09/californias-delta-poised-to-become-massive-carbon-bank**. *Accessed May 13, 2022*

LAND COVER AND CARBON STOCKS IN THE COUNTY

Carbon stocks and emission potential varies by land type. For example, in croplands, carbon stocks are not as heavily influenced by wildfire, because they are generally irrigated and heavily managed landscapes, while shrubland and forests may be more susceptible to losses from wildfire. Alternatively, when land is improperly managed and soil nutrients are depleted through heavy tillage, monocropping, and other damaging practices, carbon stocks can become more volatile. In Contra Costa County, the increasing trend towards development can lead to a conversion of wildland or agricultural landscapes to other uses that can result in carbon stock losses.

In 2021, developed land cover totaled an estimated 40,921 acres making up nearly a quarter of county lands. Grassland is the largest land cover type, making up approximately 30 percent of county land cover. Forested land cover, such as oak woodlands, is the third largest land cover type, making up nearly 17 percent of county lands. ***FIGURE 5*** maps the total estimated carbon stock proportions of each land cover classification across Contra Costa County by carbon stock per acre. ***FIGURE 6*** maps the total estimated carbon stocks for Contra Costa County.

FIGURE 5. 2021 Carbon Stocks by Land Cover

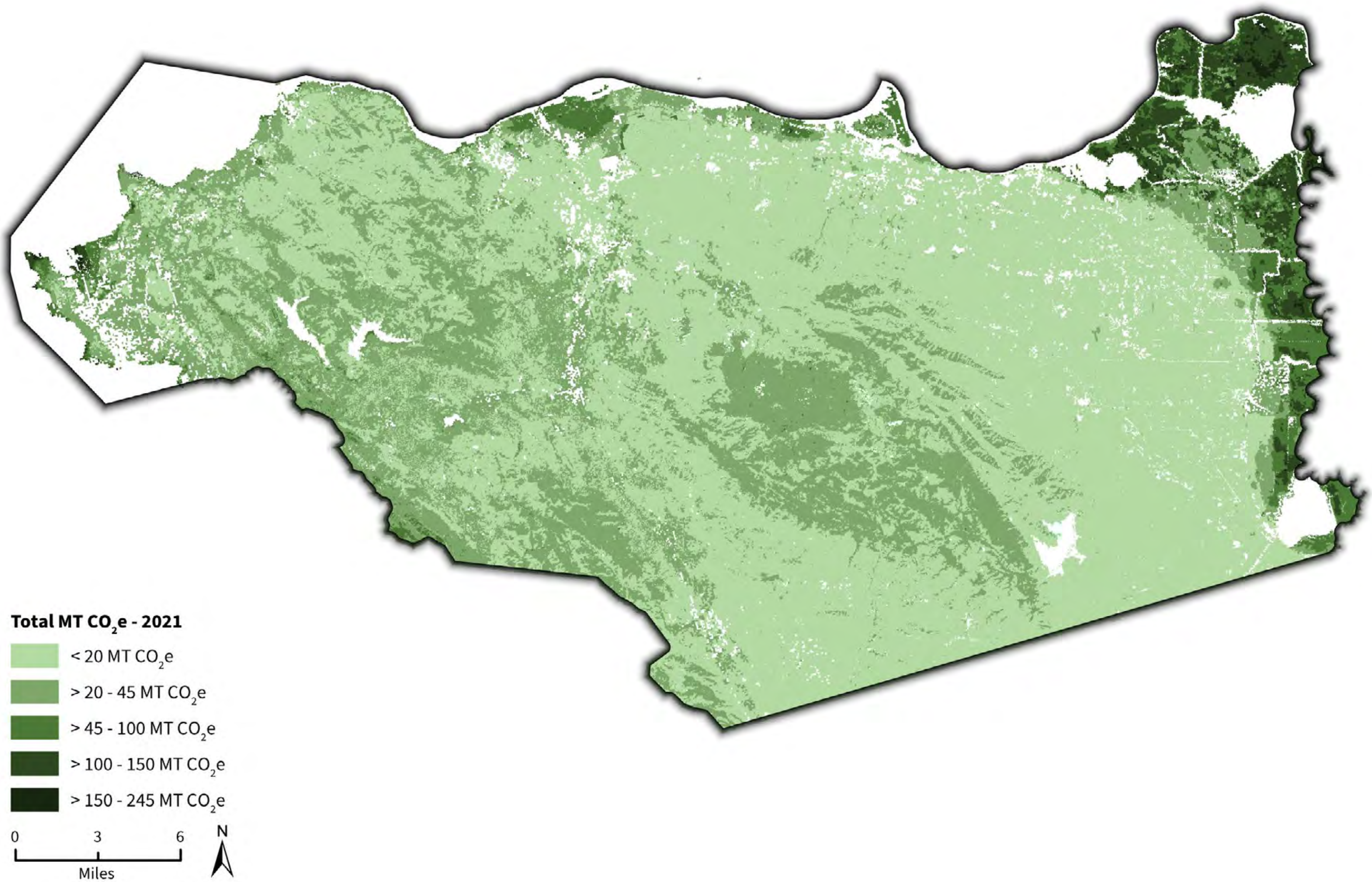


Percentages are rounded and do not add to 100%.

◆ *Total Carbon Stock (2021)*

■ *Average Carbon Stock per Acre (2021)*

FIGURE 6. 2021 Contra Costa County Carbon Stocks



4.

CARBON SEQUESTRATION ACTIVITIES AND ANALYSES

WHAT CARBON SEQUESTRATION ACTIVITIES CAN BE EMPLOYED IN CONTRA COSTA COUNTY?

This section describes the various carbon sequestration activities that can reduce net GHG emissions by pulling carbon from the air and storing it in the ground and in plants. Carbon sequestration and climate smart activities for agricultural, natural, and urban lands are included in the analysis. Each of these categories has corresponding activities that provide a strategy for carbon sequestration and associated co-benefits. These activities range from improved nitrogen fertilizer management to urban forestry. Each of these activities plays a specific role in utilizing the opportunities presented with NWLs in climate change mitigation efforts. See ***Appendix D***, ***Appendix E***, and ***Appendix F*** for the full methodology and detailed calculations.

- Carbon sequestration activities considered were drawn from a number of established programs and models including:
- California Department of Food and Agriculture Healthy Soils Program
- USDA Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP)
- COMET-Planner
- TerraCount Activity Sheets, developed by the Department of Conservation and the Nature Conservancy
- CARB Land Restoration Benefits Calculator
- NRCS Carbon Sequestration Ranking Tool

Carbon sequestration activities and practices were reviewed by UC Cooperative Extension, Contra Costa RCD, and other stakeholders with local knowledge and institutional expertise to evaluate the applicability to Contra Costa County.

The carbon sequestration estimates produced as part of this analysis use the current best practices and best available methodology and data. However, modeling continues to change and improve, and more refined data or calculation protocols may become available in the future. Not all possible climate smart activities are currently included in ***IPCC***-based protocols, and not all climate smart activities are applicable to Contra Costa County. Therefore, there are some activities that are not regionally appropriate that were not included, and there are some applicable but currently unquantifiable activities that are not included in this carbon sequestration analysis that may nonetheless sequester carbon, reduce carbon stock losses, and/or provide additional co-benefits beyond what is estimated here. Climate change brings with it some level of uncertainty, and additional unforeseen impacts may also affect actual carbon sequestration and carbon stock changes in county lands.

CARBON SEQUESTRATION ACTIVITY RESULTS SUMMARY

FIGURE 7 shows the top five climate smart activities by carbon sequestration potential across the natural and working lands categories. Compost application to rangelands is the activity with the highest sequestration potential, followed by compost application and nutrient management on row crops and then urban forestry.

Compost application and nutrient management on row crops has a high potential for sequestration and adoption. Compost application to rangelands has a high sequestration potential, but potential adoption is constrained based on rangeland health, access to equipment, presence of wildlife, soil types, and cost among other considerations. Additional support for compost application would be warranted given the outsized carbon sequestration potential of the practice. Urban forestry has a large potential for increasing carbon sequestration, but also poses challenges for increased adoption due to varied jurisdictional priorities, cost, maintenance requirements, and constrained suitable space. These constraints are not insurmountable but would require planning and resources to increase implementation and achieve some of the large potential carbon sequestration benefits they offer. Refer back to ***FIGURE 4***, Summary of Challenges and Opportunities for more detail on the constraints and opportunities for each NWL category. The following sections describe how the potential for these carbon sequestration activities were developed as well as the associated carbon sequestration potential.

Top Five Sequestration Activities

1. Compost Application
2. Nutrient Management and Compost Application
3. Urban Forestry
4. Alley Cropping
5. Riparian Forest Buffer

NWL Categories

CROPLANDS-SPECIFIC ACTIVITIES

- Row crop activities
- Orchard only activities
- Vineyard only activities
- Orchard and vineyard only activities

URBAN FARM AND URBAN LANDS ACTIVITIES

NATURAL, RANGELAND, AND PASTURE ACTIVITIES

FIGURE 7. Top Five Carbon Sequestration Activities by Sequestration Potential across NWLs

TOP FIVE SEQUESTRATION ACTIVITIES

1. Compost Application

(Grazing Lands) Applying decayed organic matter to soil. Improves soil structure through the addition of carbon and provides plant nutrients.

Carbon Sequestration Potential

43,788 to 291,917 MT CO_2e

2. Nutrient Management and Compost Application

(Row Crops) Manage rate, source, placement, and timing of plant nutrients and soil amendments, including compost application, whil reducing environmental impacts.

Carbon Sequestration Potential

12,807 to 85,377 MT CO_2e

3. Urban Forestry

Maintaining existing trees and planting new trees in urban areas.

Carbon Sequestration Potential

27,957 to 69,893 MT CO_2e

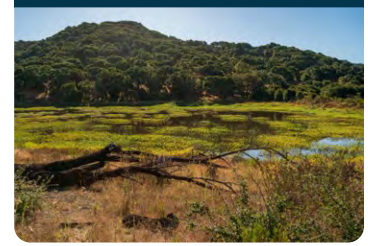
4. Alley Cropping

Trees or shrubs are planted in sets of single or multiple rows with agronomic, horticultural crops or forages produced in the alleys between the sets of woody plants that produce additional products.

Carbon Sequestration Potential

3,281 to 21,874 MT CO_2e

5. Riparian Forest Buffer



Conserving, maintaining, and restoring forested areas adjacent to permanent or intermittent streams, lakes, ponds, and wetlands.

Carbon Sequestration Potential

2,993 to 19,950 MT CO_2e

Croplands

Urban Farm and Forest

Natural, Rangelands, and Pasture

NWL CATEGORIES

CARBON SEQUESTRATION ACTIVITY IMPLEMENTATION

A range of potential implementation acreages was used for each carbon sequestration practice analyzed. Implementation acreages were created to provide a range of carbon sequestration potentials based on the amount of land, by land cover type, to which a climate smart practice is potentially applicable. ***TABLE 1*** shows the low- and high-implementation acreages for each carbon sequestration activity. These ranges are meant to provide a range of potential implementation acreages for comparison purposes and to help guide prioritization of climate smart practice adoption efforts by identifying the practices and application areas with the largest potential for carbon benefits. Actual implementation acreages for any given practice will depend on numerous factors including policy, funding, engagement, and other mitigating circumstances.

Higher implementation rates are meant to illustrate the opportunities and potential for additional carbon sequestration, while actual adoption rates are likely to be much lower.

Considering discussions of current and future adoption of practices amongst the Healthy Lands, Healthy People project team and feedback from the UC Cooperative Extension Survey and Focus Group Sessions, it is likely that farmers and ranchers are more likely to implement practices that have the least negative impact on their day-to-day operations and budgets. This means that practices that reduce the area of farmable land or associated with high costs and without strong or near-term financial benefits, are less likely to be implemented.

Higher adoption rates are expected for practices such as cover cropping, mulching, and hedgerow and windbreak installation, as they are less likely to interfere with farm operations. Carbon sequestration activities in wildland areas may be constrained by jurisdiction, species protections, and the costs of implementation and maintenance. Real world urban forestry implementation acreage is constrained by several factors, including jurisdictional priorities in incorporated cities, tree planting and maintenance costs, powerlines and underground utilities, and limited open space for planting. Large scale urban forest expansion would require cooperation, planning, and funding beyond the jurisdictional limits of the unincorporated county. For a more in-depth discussion of implementation acreages see ***Appendix F***.

TABLE 1. Carbon Sequestration Activities

Activity	CPS Code*	Description	Low Implementation (acres)	High Implementation (acres)	Current Adoption Rate	Potential Adoption Rate
CROPLANDS-SPECIFIC ACTIVITIES						
Row Crop Activities						
Cover Cropping	CPS 340	Add Legume Seasonal Cover Crop to Irrigated Cropland, Multiple Species	2,878	19,186	Low	High
Mulching	CPS 484	Add Mulch to Croplands, Wood Chips or Natural Materials	1,869	12,460	Low	Low
Compost Application and Nutrient Management	CPS 808/ CPS 590	Replace Synthetic N Fertilizer with Compost C:N Ratio > 11 on Irrigated Croplands	2,878	19,186	Low Medium	High
Hedgerow Planting	CPS 422	Replace a Strip of Cropland with 1 Row of Woody Plants, Single Row	78	517	Low	High
Windbreak/ Shelterbelt Establishment	CPS 380	Replace a Strip of Cropland with 1 Row of Woody Plants	110	735	Low	Medium
Riparian Forest Buffer	CPS 391	Replace a Strip of Cropland Near Watercourses or Water Bodies with Woody Plants	0**	0**	N/A	N/A
Riparian Herbaceous Cover	CPS 390	Convert Irrigated Cropland to Permanent Unfertilized Grass/Legume Cover Near Aquatic Habitats	0**	0**	N/A	N/A
Field Border	CPS 386	Convert Strips of Irrigated Cropland to Permanent Unfertilized Grass/Legume Cover	369	2,461	Low	Low
Alley Cropping	CPS 311	Replace 20% of Annual Cropland with Woody Plants, Tree Planting/Single Row	4,101	27,342	Low	Low
Conservation Crop Rotation	CPS 328	Decrease Fallow Frequency or Add Perennial Crops to Rotations	4,101	27,342	Low	Low
Residue and Tillage Management - Reduced Till	CPS 345	Reduced Till, Intensive Till to Reduced Till on Irrigated Cropland, Reduced Till	4,101	27,342	Low	Medium

Activity	CPS Code*	Description	Low Implementation (acres)	High Implementation (acres)	Current Adoption Rate	Potential Adoption Rate
Residue and Tillage Management - No Till	CPS 329	No Till, Intensive Till to No Till or Strip Till on Irrigated Cropland, No-Till or Strip Till	4,101	27,342	Low	Low
Orchard and Vineyard Activities						
Cover Cropping	CPS 340	Add Legume/Legume Mix Cover Crop to Orchard/Vineyard Alleys	472	3,149	Medium	High
Mulching	CPS 484	Add Mulch to Orchard/Vineyards	463	3,086	Low	High
Compost Application and Nutrient Management	CPS 808/ CPS 590	Replace Synthetic N Fertilizer with Compost C:N Ratio > 11 on Irrigated Croplands	462	3,082	Low Medium	High
Hedgerow Planting	CPS 422	Plant 1 Row of Woody Plants on Border or Orchard or Vineyard, Single Row	18	117	Low	High
Windbreak/ Shelterbelt Establishment	CPS 380	Plant 1 Row of Woody Plants on Border or Orchard or Vineyard	17	114	Low	High
Vineyard Only Activities						
Residue and Tillage Management - Reduced Till	CPS 345	Reduced Till, Conventional Till to Reduced Till in Orchard/Vineyard Alleys, Reduced Till	185	1,236	N/A	N/A
Residue and Tillage Management - No Till	CPS 329	No Till, Conventional Till to No Till in Orchard/Vineyard Alleys	185	1,236	N/A	N/A
Orchard Only Activities						
Residue and Tillage Management - Reduced Till	CPS 345	Reduced Till, Conventional Till to Reduced Till in Orchard/Vineyard Alleys, Reduced Till	227	1,513	N/A	N/A
Residue and Tillage Management - No Till	CPS 329	No Till, Conventional Till to No Till in Orchard/Vineyard Alleys	227	1,513	N/A	N/A
Whole Orchard Recycling	CPS 808	Whole Orchard Recycling Followed by Orchard Replant within 3 Years	324	2,162	Low	High

Activity	CPS Code*	Description	Low Implementation (acres)	High Implementation (acres)	Current Adoption Rate	Potential Adoption Rate
URBAN FARM AND URBAN LAND ACTIVITIES						
Cover Cropping	CPS 340	Add Legume Seasonal Cover Crop to Irrigated Cropland, Multiple Species	2	16	Medium	High
Mulching	CPS 484	Add Mulch to Croplands, Wood Chips or Natural Materials	3	23	Medium	High
Compost Application and Nutrient Management	CPS 808/ CPS 590	Replace Synthetic N Fertilizer with Compost C:N Ratio > 11 on Irrigated Croplands	3	21	Medium	High
Hedgerow Planting	CPS 422	Replace a Strip of Cropland with 1 Row of Woody Plants, Single Row	0.15	1	Medium	High
Windbreak/ Shelterbelt Establishment	CPS 380	Replace a Strip of Cropland with 1 Row of Woody Plants	1	5	Low	Low
Field Border	CPS 386	Convert Strips of Irrigation Cropland to Permanent Unfertilized Grass/Legume Cover	3	20	N/A	N/A
Alley Cropping	CPS 311	Replace 20% of Annual Cropland with Woody Plants, Tree Planting/Single Row	11	72	N/A	N/A
Conservation Crop Rotation	CPS 328	Decrease Fallow Frequency or Add Perennial Crops to Rotations	11	72	Medium	High
Residue and Tillage Management - Reduced Till	CPS 345	Reduced Till, Intensive Till to Reduced Till on Irrigated Cropland, Reduced Till	11	72	High	High
Residue and Tillage Management - No Till	CPS 329	No Till, Intensive Till to No Till or Strip Till on Irrigated Cropland, No-Till or Strip Till	11	72	Medium	High
Urban Forestry	N/A - TerraCount	Planting of trees in urban areas, resulting in increased urban tree canopy cover	1,260	3,150	N/A	N/A

Activity	CPS Code*	Description	Low Implementation (acres)	High Implementation (acres)	Current Adoption Rate	Potential Adoption Rate
NATURAL, RANGELAND, AND PASTURE ACTIVITIES (RANGELANDS ARE USED FOR GRAZING LIVESTOCK)						
Restoration of Native Grasses	N/A – TerraCount	Restoration of native grasses to a site currently dominated by non-native grasses	7,742	23,226	N/A	N/A
Oak Woodland Restoration	N/A - TerraCount	Restoration of oak woodlands (across the ranges of blue oak and valley oak) in areas where present-day land cover is grassland or other candidate land cover classes	7,742	23,226	N/A	N/A
Riparian Restoration	N/A - TerraCount	Restoration of woody riparian vegetation in areas near streams and rivers	60	120	N/A	N/A
Fuel Reduction	N/A - TerraCount	Fuel treatment to remove excess biomass from forested areas. Emission reductions are based on changes in on-site biomass over time, and probabilistic emissions from future wildfires after fuel reduction treatments have been performed on the site.	6,533	17,421	N/A	N/A
Compost Application to Rangelands	CPS 808	One-time application of compost to rangelands to increase soil organic carbon and water holding capacity	9,645	64,299	Low	Low
Prescribed Grazing (Rangelands)	CPS 528	Grazing Management to Improve Rangeland or Non-Irrigated Pasture Condition, Range/Basic	22,200	148,000	Medium	High
Prescribed Grazing (Pasture)	CPS528	Grazing Management to Improve Irrigated Pasture Condition, Pasture/Basic	818	5,450	Medium	High
Native Oak Restoration/ Silvopasture	CPS 381	Tree/Shrub Planting on Grazed Grasslands, Establish Trees in Existing Grasses	1,293	8,622	Low	Low
Riparian Restoration	N/A – TerraCount	Woody plantings on degraded streambanks, which are characterized by lack of vegetation, allowing the movement of heavy runoff through the riparian zone directly into stream channels.	327	2,178	Medium	High
Range Planting	CPS 550	Seeding Forages to Improve Rangeland Condition	3,384	22,563	Low	Low

**CPS Code refers to the National Resources Conservation Service (NRCS) Conservation Practice Standards (CPS) reference number. CPS sheets are technical guides, and the primary scientific references used by the NRCS to help in planning conservation projects.*
***GIS analysis was unable to differentiate between natural riparian corridors and irrigation ditches, and therefore was unable to identify implementation acreages for riparian restoration in croplands. However, there may be places where riparian restoration is possible on farms, this activity simply was excluded from this analysis due to data limitations.*

CARBON SEQUESTRATION POTENTIAL ESTIMATE MATRIX

The results of the carbon sequestration potential analysis are provided in ***TABLE 2***. Activities are grouped by land use category and the annual carbon sequestration potential is estimated for both the low and high implementation acreages analyzed. The activity with the greatest carbon sequestration potential is urban forestry, followed by compost application to rangelands, alley cropping, and riparian restoration on grazing lands. The urban forestry activity includes carbon sequestration estimates for both planting new trees and maintaining existing trees. The high carbon sequestration potential of urban forestry is due to a combination of low leakage risk,[21] high per acre annual GHG reduction rate compared to other activities included in the analysis, and fewer barriers to implementation compared to agricultural strategies.

An important caveat to interpretation of this table is that acreage shown should not be summed. Many of these practices are duplicative or overlapping on the same land area. Totaling the acreage would result in double counting in some cases and therefore produce an inaccurate total estimate of sequestration and acreage potential.

As an example, a farmer cannot do both “Residue and Tillage Management - No-Till” and “Residue and Tillage Management - Reduced Till” in the same field. As another example, “Cover Crop'' and “Conservation Crop Rotation” are duplicative, with cover cropping potentially included in the conservation crop rotation. In practice, many of these management practices can be implemented simultaneously on the same acreage (no till and cover cropping, for example), but we refrain from summing the tables and instead use the figures to begin a discussion of these management practices and their ability to sequester GHGs.

TABLE 2. Estimated Annual Carbon Sequestration Potential by Activity

Activity	Low Implementation Carbon Sequestration Potential (MT CO_2e/ Year)	High Implementation Carbon Sequestration Potential (MT CO_2e/ Year)
CROPLANDS-SPECIFIC ACTIVITIES		
Row Crop Activities		
Cover Cropping (CPS 340)	1,151	7,674
Mulching (CPS 484)	392	2,617
Compost Application and Nutrient Management (CPS 590)	12,807	85,377
Hedgerow Planting (CPS 422)	642	4,279
Windbreak/Shelterbelt Establishment (CPS 380)	913	6,090
Riparian Forest Buffer (CPS 391)	0	0

21. *The leakage definition used in the TerraCount activity sheets is: “Carbon leakage refers to the displacement of GHG emissions from one place to another due to emission reduction activities. It is caused by a direct or indirect shift of activities that create those emissions from within an emissions accounting system to out of that system.” This definition is from Henders and Ostwald (2012) in their review of leakage accounting mechanisms from both the published literature and existing project accounting standards. In other words, leakage is the release of GHG emissions from implementation of an emissions reduction activity.*

Activity	Low Implementation Carbon Sequestration Potential (MT CO_2e/ Year)	High Implementation Carbon Sequestration Potential (MT CO_2e/ Year)
Riparian Herbaceous Cover (CPS 390)	0	0
Field Border (CPS 386)	498	3,322
Alley Cropping (CPS 311)	3,281	21,874
Conservation Crop Rotation (CPS 328)	1,066	7,109
Residue and Tillage Management - Reduced Till (CPS 345)	369	2,461
Residue and Tillage Management - No Till (CPS 329)	738	4,922
Orchard and Vineyard Activities		
Cover Cropping (CPS 340)	775	5,164
Mulching (CPS 484)	157	1,049
Compost Application and Nutrient Management (CPS 590)	2,104	14,025
Hedgerow Planting (CPS 422)	143	956
Windbreak/Shelterbelt Establishment (CPS 380)	140	931
Vineyard Only Activities		
Residue and Tillage Management - Reduced Till (CPS 345)	22	148
Residue and Tillage Management - No Till (CPS 329)	65	433
Orchard Only Activities		
Residue and Tillage Management - Reduced Till (CPS 345)	27	182
Residue and Tillage Management - No Till (CPS 329)	79	530
Whole Orchard Recycling (CPS 808)	13	86

Activity	Low Implementation Carbon Sequestration Potential (MT CO_2e/ Year)	High Implementation Carbon Sequestration Potential (MT CO_2e/ Year)
URBAN FARM AND URBAN LAND ACTIVITIES		
Cover Cropping (CPS 340)	1	6
Mulching (CPS 484)	1	5
Compost Application and Nutrient Management (CPS 590)	14	95
Hedgerow Planting (CPS 422)	2	11
Windbreak/Shelterbelt Establishment (CPS 380)	6	39
Field Border (CPS 386)	4	25
Alley Cropping (CPS 311)	9	58
Conservation Crop Rotation (CPS 328)	3	19
Residue and Tillage Management - Reduced Till (CPS 345)	1	9
Residue and Tillage Management - No Till (CPS 329)	2	16
Urban Forestry	27,957	69,893
NATURAL, RANGELAND, AND PASTURE ACTIVITIES (RANGELANDS ARE USED FOR GRAZING LIVESTOCK)		
Restoration of Native Grasses	773	2,320
Oak Woodland Restoration	1,871	5,613
Riparian Restoration	7	15
Fuel Reduction	1,089	2,904
Compost Application to Rangelands	43,788	291,917
Prescribed Grazing (CPS 528) (Rangelands)	187	1,248
Prescribed Grazing (CPS528) (Pasture)	86	573
Native Oak Restoration/Silvopasture (CPS 381)	854	5,691
Riparian Forest Buffer	2,993	19,950
Range Planting (CPS 550)	1,304	9,532

ACTIVITIES NOT INCLUDED IN THE ANALYSIS

Wetland restoration projects were not included in this analysis due to the complex and site-specific nature of the biogeochemical processes that determine whether an individual wetland will be a net source or sink for GHGs. Furthermore, this landscape and other blue carbon land cover types (carbon captured and held in coastal vegetation and soils, such as seagrasses, seaweeds, and wetlands) are not currently covered by IPCC inventory guidelines or included in California's NWL Inventory. California's Ocean Protection Council and San Francisco Estuary Institute are partnering to create a new coastal wetlands, beaches, and watersheds inventory. CARB will incorporate wetlands into future modeling when more data and improved methodology become available. Until that time, wetland restoration can serve as an important ecological resource with many co-benefits and carbon sequestration potential, even if that is not reflected in this analysis.

Additional activities such as cultural burning, conservation, and numerous others are also not included in the CARB models of climate actions to support the NWL targets but are listed in the Scoping Plan and California Climate Smart Strategy as additional practices that can reduce emissions from land disturbance and increase carbon stocks. Many of these practices do not have established methodologies for estimating carbon sequestration at this time; the required data is not currently available, or it was otherwise not possible to analyze potential carbon sequestration for implementation in Contra Costa County at this time. Section 6 of this report identifies some additional practices, as well as emerging policy and funding opportunities that could not be incorporated into the analysis now but may be useful for future modeling, planning, and implementation efforts.

CO-BENEFITS OF CARBON SEQUESTRATION PRACTICES

Sequestering carbon is one of many benefits that are provided by healthy management and conservation of NWLs. Efforts to increase carbon storage must consider the potential impacts, both positive and negative, on other benefits, known as complementary benefits (co-benefits). Assessing co-benefits of different management activities allows for prioritization of these activities based not only on carbon sequestration potential, but also on other important factors (for example, agricultural quality, human well-being, water supply and quality, air quality, and equity). A discussion of several co-benefits affected by the activities included in the Carbon Sequestration Analysis are provided below along with a description of each. The analysis is qualitative, and the extent of actual positive effects on co-benefits for practices will depend on site specific conditions.

This list of co-benefits was derived from the TerraCount Activity Sheets and the Nature-Based Solutions Explorer Tool. These sources allow for scoring of each carbon sequestration activity based on the number of different associated co-benefits. However, due to lack of substantial research regarding co-benefits, evaluation and scoring of co-benefits is open to discussion. An exploratory co-benefits assessment for the activities included in this analysis are provided in ***Appendix G***.

WATER QUALITY AND QUANTITY CO-BENEFITS

Ag/Urban Water Conservation

Changes in water use driven by land use change or changes in management practices on land.

Improved Surface Water Storage

More surface water is stored through increased infiltration and retention in soil. Improved surface water storage has multiple beneficial uses that include drinking water supply, recreation, bathing, agriculture, industry, fisheries, and property value. A range of NWL protection, restoration, and management practices can be implemented to reduce the pollutant load (sediment, excess nutrients, fecal matter, heavy metals and oils, etc.).

Improved Surface and Groundwater Quality

Changes in the chemical, physical, and biological characteristics of water important for ecological and human health. Surface water storage includes water accumulated on the soil surface or water retained in depressions (floodplains, lakes, swamps, pools). Surface water is very accessible and thus has many uses including irrigation, drinking water, and energy generation.

Groundwater Recharge and Storage Potential

Changes in groundwater recharge from scenarios that convert natural lands to development. Improving surface and groundwater quality has multiple beneficial uses that include drinking water supply, recreation, bathing, agriculture, industry, fisheries, and property value. A range of protection, restoration, management, and creation interventions can be implemented to reduce the pollutant load (sediment, excess nutrients, fecal matter, heavy metals and oils, etc.).

Reduced/Avoided Surface Runoff/ Erosion

Lessening water runoff helps maintain a potential water resource, as well as prevent damaging soil erosion.

Improved Flow Regime

A flow regime is the pattern or description of the flow structure or distribution of one fluid phase relative to the other. Removing barriers can restore a stream to its natural flow regime.

Improved Flood Protection/Mitigation

Flood protection and mitigation involves managing or controlling flood water movement and can be improved and maintained through natural systems. For instance, restoration of wetlands, salt marshes, oyster reefs, and mangroves can reduce wave energy, minimize the impact of storm surges, and slow down water runoff reducing flood risk and protecting communities.

Watershed Integrity

Estimated based on the following metrics: riparian areas degraded, important riparian buffer, and natural catchment.

BIODIVERSITY AND ENVIRONMENT CO-BENEFITS

Terrestrial Connectivity

Refers to the unimpeded movement of species and the flow of natural processes that sustain life on Earth. Connectivity is one of the essential enabling factors for successful preservation and restoration of terrestrial and aquatic biodiversity, and includes the concepts of dispersal, seasonal movements and migrations, fluvial processes and the connectivity that is inherent to naturally functioning areas. In terrestrial conservation, this concept describes linkages between habitats, such as corridors or nodes that allow wildlife to move freely, access resources, and escape from external threats.

Priority Conservation Areas

Land cover in priority conservation areas (e.g., Association of Bay Area Governments [AMBAG] and Metropolitan Transportation Commission [MTC] priority conservation areas, Audubon important bird areas, and California Department of Fish and Wildlife essential connectivity areas).

Aquatic Habitat Availability and Quality

Dependent on the size, shape, connectivity with water sources (surface or groundwater), presumed depth, current, velocity and substrate type. These factors influence the productivity, accessibility, and sustainability of the plant and animal communities dependent upon aquatic habitats. Many organisms are limited in their recovery by restricted habitat availability. Habitat quality affects the distribution of individuals in space and influences the potential for resource acquisition. A poor habitat can entail decreased survival of terrestrial species.

Terrestrial Habitat Value and Soil Health

Terrestrial habitat value for mammals, birds, amphibians, reptiles, and threatened and endangered species. Terrestrial habitat availability is dependent on the size, shape, and cover type. These factors influence the productivity, accessibility, and sustainability of the plant and animal communities dependent upon terrestrial habitats. Many organisms are limited in their recovery by restricted habitat availability. Habitat quality affects the distribution of individuals in space and influences the potential for resource acquisition. A poor habitat can entail decreased survival of terrestrial species.

Increased Native Animal Species

Maintained or increased abundance (the measure of the number or frequency of individuals of the same species) and diversity (number or species present) of native animal species.

Increased Native Plant Species

Maintained or increased abundance (the measure of the number or frequency of individuals of the same species) and diversity (number or species present) of native plant species.

Natural Pest Control

A method of controlling pests without using chemicals. Instead, other insects, birds, animals, plants, or mechanical techniques are used.

Support for Local Pollinators

Pollinators are essential to global agriculture. In addition to direct benefits on people and the economy, the health and abundance of native pollinators are foundational to the function of many natural systems and to the plants and animals that rely on them.

Aquatic Biodiversity Value/ Richness

Land cover in watersheds with important aquatic habitat (as defined by The Nature Conservancy's Freshwater Blueprint).

HUMAN WELLBEING AND SOCIOECONOMICS

Air Quality and Enhanced Microclimate Regulation

Estimates air pollution (nitrogen dioxide - NO_2, sulfur dioxide - SO_2, carbon dioxide - CO_2, ozone - O_3, particulate matter 2.5 - $PM_{2.5}$, and particulate matter 10 - PM_{10}) removed by plants, mainly by uptake through the stomata of leaves. Activities that are implemented in primarily urban settings can mitigate urban heat island effect, a phenomenon in which air temperatures in cities are substantially higher than in adjacent rural areas.

Scenic Value

Improved visibility of areas developed from public areas, parks, and roadways.

Improved Human Health/ Livelihood

Livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.

Opportunities for Education/Science

Nature-based solution activities are usually implemented after conducting scientific feasibility studies, and the impacts of activities are monitored throughout the project (i.e., from the start to the finish and beyond). Data gathered on both environmental and socio-economic information can be used for wider scientific and economic studies, to understand general trends and natural phenomena.

Increased Food Security

Through protecting and restoring natural resources and ecosystem services, activities can improve agricultural performance and provide a mechanism for greater food security.

Increased Property/ Land Value

The state and functioning of local landscape features (such as surrounding vegetation, aquatic systems, etc.) also influence the value of properties and land. Activities can enhance landscapes, with property/landowners and surrounding communities benefitting from additional or enhanced ecosystem services.

Improved Recreation and Tourism

Creating, protecting, or restoring green spaces in cities and rural areas through activities can increase tourism revenues, as these public spaces become more attractive to locals and visitors.

Flood Risk Reduction

Tracks acreage of development in the 100-year floodplain. Increases water infiltration into the ground, helps reduce or manage peak flows, or otherwise reduce the likelihood of stormwater flooding.

ENHANCED BENEFITS FROM STACKING CLIMATE SMART PRACTICES

It is important to utilize a diversity of practices in order to better mimic natural, healthy systems. When climate smart practices, such as composting, cover cropping, mulching, etc., are utilized in tandem, or stacked, both carbon sequestration capacity and co-benefits are increased. For example, rotating plantings of cover crops between cash crops can add carbon to the soil. When compost is applied to land regularly, the overall capacity to store carbon in soil is increased. Thus, if composting and cover cropping practices are stacked together, the soil carbon storage capacity is increased from compost application, meaning that more carbon from cover crops can be sequestered. Additionally, co-benefits of stacking climate smart practices may include increased water retention, decreased nutrient leaching, reduced erosion, among others.[22]

CARBON FARMING CASE STUDIES

As data continues to emerge about the benefits of climate smart agricultural (CSA) practices, many producers in California have shown interest in or have implemented carbon farm plans, with goals of improving their climate impact, soil health, overall productivity, and profitability. The case studies presented in ***TABLE 3***, at various farms in Central California, provide a snapshot of the benefits that were incurred at each site when CSA practices were adopted.

22. *Bai, Xiongxiong, Yawen Huang, Wei Ren, Mark Coyne, Pierre A. Jacinthe, Bo Tao, Dafeng Hui, Jian Yang and Christopher John Matocha. "Responses of soil carbon sequestration to climate-smart agriculture practices: A meta- analysis." Global Change Biology 25 (2019): 2591–2606.*

TABLE 3. Carbon Farm Plan Case Studies

Farm Name	Location	Farm Type	Practices Adopted	Benefits Incurred
Urban Tilth*	Richmond, California	Urban Farm; mixed vegetables	• Cover Cropping • Hedgerows • Mulching • Compost Application • No-Till • Conservation Cover • Riparian Herbaceous Cover • Residue and Tillage Management	• Estimated 183.65 tons CO_2e could be sequestered in soils, as well as above and below-ground biomass over 20 years. • Potential additional on-farm carbon capture over this period through the reapplication of compost, through the renovation of hedgerows at maturity and through the implementation of other carbon-beneficial practices not currently included in this carbon farm plan.
Faith Home Orchard**	Ceres, California	Almond Orchard	• Cover Cropping • Whole Orchard Recycling	• Crop yield increase • Decreased costs • Improved soil water filtration and capacity • Cover crop practices resulted in average reduction of 32 tons CO_2e/year • Pollinator Habitat • Improved Soil Health
Okuye Farms**	Merced County, California	Almond Orchard	• Cover Cropping • Nutrient Management • Compost Application • Mulching Conservation Cover	• Crop yield increase • Decreased costs • Increase of beneficial insects • Increased soil organic matter • Improved water holding capacity • Reduced nitrogen losses by 98% • 16% reduction in total GHG emissions • Improved soil health

** This carbon farm plan was developed as part of the Contra Costa County Department of Conservation and Development's "Healthy Lands, Healthy People" grant, funded by the California Department of Conservation's 2020 Sustainable Agricultural Lands Conservation Grant Program.*
*** American Farmland Trust and partners developed 15 compelling and easy-to-read, two-page soil health economic and environmental case studies featuring "soil health successful farmers."*

5.

MOVING FORWARD

COUNTY MEASURES AND ACTIONS

NWLs strategies will play a critical role in allowing Contra Costa County to help the State reach its 2045 carbon neutrality goal. Rincon developed measures and actions based on the analysis of carbon sequestration potential across lands in Contra Costa County. The measures provide the overall strategy and goal the County hopes to achieve with the implementation actions that are detailed in each measure and action table on the following pages.

Action

The NWL actions define the specific policies, programs, and steps the County and its partners will implement to achieve the NWL measures and support the Contra Costa County Healthy Lands, Healthy People approach to sustainability.

Lead and Partners

Each action has identified the potential action/project lead that would spearhead the proposed action and partnership entities that would be important to engage for effective implementation of the proposed action.

Implementation Phase

The County has identified three phases for implementation:

Phase 1 actions are those being implemented before development of the Carbon Sequestration Feasibility Study Report or beginning implementation before 2024. These actions have been prioritized due to their importance, cost-effectiveness, or the availability of resources for implementation.

- Before and during Phase 2, monitor and update the measures and actions in Phase 1, as necessary, based on barriers encountered and lessons learned.

Phase 2 actions will begin implementation between 2024 and 2026. These actions may require additional resources, such as staff time, funding and financing, or there may need to be additional education and outreach conducted prior to implementation.

- Before and during Phase 3, monitor and update the measures and actions in Phases 1 and 2, as necessary, based on barriers encountered and lessons learned.

Phase 3 actions will begin implementation after 2026. These actions may be less critical in the short-term, or simply require more significant resources to implement.

Implementation Criteria

The actions have also been developed using a set of implementation criteria that have proven to lead to successful and equitable implementation of climate actions. In the measures tables on the following pages, the implementation criteria applicable to each action are listed in the "Criteria" column. The implementation criteria:

- Establish **structural change** through governance policies, institutional structures, and monitoring processes to implement actions
- Identify **funding** needs, establish funding mechanisms, and allocate adequate funding to support policy development and action implementation
- Foster collaborative **partnerships** with local stakeholders
- Promote **equity,** foster community resilience, and protect the County's most vulnerable populations
- Focus meaningful and active **education and engagement** with community members

Performance Indicator

The tables below provide NWL measures and associated actions, key performance indicators, phase, and co-benefits used to aid implementation of the County's 2030 CAP and achieve carbon neutrality by 2045.

NWLs solutions should be paired with restoration and ecosystem management strategies to maximize benefits and co-benefits.

CARB Scoping Plan Strategies Alignment

Actions that contribute to the achievement of State goals outlined in the CARB 2022 Scoping Plan are listed by category and strategy number as defined in ***Appendix H***, California Natural Working Lands Strategies. Where an action does not directly align with one of the Scoping Plan Strategies "N/A" is listed, but these actions would still contribute to climate and sustainability benefits for Contra Costa County.

FIGURE 8. How to Read the Measures and Actions Implementation Tables

Actions

Actions define the specific policies, programs, and steps the County and its partners will implement to achieve the NWL measures.

Lead & Partners

Each action has identified the potential action/project lead that would spearhead the proposed action and partnership entities that would be important to engage for effective implementation of the proposed action.

Implementation Phase

Phase 1 - Implementation before 2024

Phase 2- Implementation between 2024 and 2026

Phase 3 - Implementation after 2023

Action	Lead	Partners	Phase	Criteria	Performance Indicator	CARB Scoping Plan Strategies Covered (Appendix H)
2.1: Develop a comprehensive conservation and habitat restoration plan to include portions of the County not represented in the East Contra Costa County Habitat Conservation Plan and other conservation efforts, to implement natural land restoration projects. Create an equitable outreach and engagement campaign during plan development and implementation. **Phase 1:** Develop a plan, including setting targets for acres of land to be restored (e.g., riparian areas, native grassland, oak forest, and wetlands) for restoration projects. Phase 2: Implement restoration projects. Phase 3: Monitor and report on progress of restoration projects	• Contra Costa County	• East Contra Costa County Habitat Conservancy • Contra Costa RCD • UCCE	• Phase 1-3	• Equity • Education, and engagement	• Phase 1: Restoration plan(s) developed • Phase 2: Restoration projects implemented • Phase 3: Acres restored1	• Forests/ shrublands/ chapparal 1, 2, 5 • Grasslands 1, 2 • Wetlands 1, 2, 3, 4, 5
2.2: Pursue funding to implement natural land restoration projects.	• Contra Costa County Sustainability Division		• Phase 2	• Funding	• Implementation funding acquired	• Forests/ shrublands/ chapparal 1, 2, 3, 5 • Grasslands 1 • Wetlands 1, 3
2.3: Increase the production of high-quality, low-contamination compost locally in alignment with Senate Bill 1383 organic waste reduction efforts.	• Contra Costa County	• Commercial waste haulers and recyclers (such as Republic Services)	• Phase 1	• Partnerships • Structural Change	• Volume compost produced	• N/A

Criteria

The actions have also been developed using a set of implementation criteria that have proven to lead to successful and equitable implementation of climate actions.

Performance Indicators

Key performance indicators aid implementation of the County's 2030 Climate Action Plan and achieve carbon neutrality by 2045.

CARB Scoping Plan Strategies

Actions that contribute to the achievement of State goals outlined in the CARB 2022 Scoping Plan are listed by category and strategy number as defined in ***Appendix H*** California Natural Working Lands Strategies.

MEASURES AND ACTIONS

MEASURE 1: Maintain and promote climate smart agricultural practices

TABLE 4. Actions for Promoting Climate Smart Agricultural Practices

Action	Lead	Partners	Phase	Criteria	Performance Indicator	CARB Scoping Plan Strategies Alignment (Appendix H)
1.1: Pursue funding, for example California Department of Food and Agriculture (CDFA) Climate Smart Agricultural programs and implement a voluntary agricultural conservation incentive program to encourage more farmers and ranchers to adopt conservation practices that have the potential to contribute to climate mitigation and enhance resilience of agricultural operations. Examples include: • Improved nitrogen fertilizer management • Cover crops • Mulching • Hedgerow planting	• Contra Costa RCD	• Contra Costa County Department of Conservation and Development • UC Cooperative Extension (UCCE)	• Phase 1	• Funding	• Agricultural conservation incentive program developed	• Croplands 1,2,3,7
1.2: Partnership of the Contra Costa Resource Conservation District, Contra Costa County Farm Bureau, UCCE, NRCS, and other stake-holders to provide outreach and education to farmers and ranchers on conservation practices that contribute to climate mitigation and increase resilience, and incentives available to adopt these practices.	• Contra Costa RCD	• Contra Costa County Farm Bureau • UCCE • NRCS • CCI • Contra Costa County Department of Conservation and Development	• Phase 1-3	• Partnerships • Education • Engagement • Equity	• Outreach and education materials developed and distributed	• Croplands 7 • All NWL 2, 3, 7

Action	Lead	Partners	Phase	Criteria	Performance Indicator	CARB Scoping Plan Strategies Alignment (Appendix H)
1.3: Provide technical assistance to farmers for developing grant applications that support healthy soil practices (e.g., fertilizer and compost) such as the CDFA Healthy Soils Incentive Program.	• Contra Costa RCD	• NRCS	• Phase 2	• Equity	• Funding secured for farmers	• All NWL 1, 3, 5, 7 • Croplands 1, 3, 7
1.4: Promote the development of conservation easements on NWLs through information sharing on the County's website, strategic partnerships, and supporting community engagement efforts.	• Contra Costa County Department of Conservation and Development	• East Contra Costa County Habitat Conservancy	• Phase 1-3	• Partnerships • Education • Engagement	• Outreach and education materials developed and distributed	• All NWL 1, 2, 7, 8, 9
1.5: Assist farmers and rangeland managers in accessing voluntary carbon markets that pay for carbon sequestration practices. Explore implementing a program to group rangelands together for more competitive grant applications, similar to the model used by the Cachuma Resource Conservation District.	• Contra Costa RCD	• CCI	• Phase 2-3	• Equity • Partnerships	• Number of participants accessing carbon markets	• All NWL 10
1.6: Promote incentives and grants (for example, CDFA Climate Smart Agriculture programs) to improve water, energy and fuel efficiency from agricultural operations.	• Contra Costa RCD	• NRCS • Farm Bureau	• Phase 1	• Education • Engagement • Partnerships • Funding	• Outreach and education about incentives and grants completed	• All NWL 6 • Croplands 3, 8, 10
1.7: Support programs, for example the Funding Agricultural Replacement Measures for Emission Reductions Program, that incentivize replacement of older, polluting farm equipment.	• Contra Costa RCD	• NRCS • Farm Bureau	• Phase 1-2	• Education • Engagement • Partnerships • Funding		• All NWL 6 • Croplands 8, 10

1. The 2021 Governor's Budget included $1.4 billion one-time General Fund over 3 years for multi-benefit s and $768 million one-time General Fund over two years to support implementation of the State's Natural and Working Lands Climate Smart Strategy and 30x30 Pathways strategy.
2. The USDA defines socially disadvantaged farmers as those who are members of one or more of the following groups whose members have been subjected to racial or ethnic prejudice because of their identity as members of a group: African Americans, American Indians, Alaska Natives, Asians, Hispanics, Pacific Islanders.

MEASURE 2: Promote conservation, restoration, and sustainable management of natural and working lands

TABLE 5. Actions for Conserving, Restoring, and Sustainably Managing NWLs

Action	Lead	Partners	Phase	Criteria	Performance Indicator	CARB Scoping Plan Strategies Covered (Appendix H)
2.1: Develop a comprehensive conservation and habitat restoration plan to include portions of the County not represented in the East Contra Costa County Habitat Conservation Plan and other conservation efforts, to implement natural land restoration projects. Create an equitable outreach and engagement campaign during plan development and implementation. **Phase 1:** Develop a plan, including setting targets for acres of land to be restored (e.g., riparian areas, native grassland, oak forest, and wetlands) for restoration projects. **Phase 2:** Implement restoration projects. **Phase 3:** Monitor and report on progress of restoration projects	• Contra Costa County	• East Contra Costa County Habitat Conservancy • Contra Costa RCD • UCCE	• Phase 1-3	• Equity • Education • Engagement	• Phase 1: Restoration plan(s) developed • Phase 2: Restoration projects implemented • Phase 3: Acres restored1	• Forests/ shrublands/ chapparal 1, 2, 5 • Grasslands 1, 2 • Wetlands 1, 2, 3, 4, 5
2.2: Pursue funding to implement natural land restoration projects.	• Contra Costa County	• Public and private land owners	• Phase 2	• Funding	• Implementation funding acquired	• Forests/ shrublands/ chapparal 1, 2, 3, 5 • Grasslands 1 • Wetlands 1, 3
2.3: Increase the production of high-quality, low-contamination compost locally in alignment with Senate Bill 1383 organic waste reduction efforts.	• Contra Costa County	• Commercial waste haulers and recyclers	• Phase 1	• Partnerships • Structural Change	• Volume compost produced	• N/A

Action	Lead	Partners	Phase	Criteria	Performance Indicator	CARB Scoping Plan Strategies Covered (Appendix H)
2.4: Develop a program to facilitate compost application on burn scars, rangelands, and applicable NWLs in the county. Increase capacity to produce high-quality, low-contamination compost locally. Prioritize compost application in and around socially disadvantaged communities.	• Contra Costa RCD	• CCI • Contra Costa County • Public and Private Landowners	• Phase 2-3	• Partnerships • Equity	• Number of acres of rangelands compost applied to; number of rangeland operations participating in the compost application program	• Grasslands 2, 3
2.5: Develop and implement a plan for the conservation of sparsely vegetated lands, such as beaches and bare rocks, that includes educating local landholders about the importance of this land type and conservation easements for private landholders on this land type.	• Contra Costa County	• East Contra Costa County Habitat Conservancy • Contra Costa RCD • UCCE	• Phase 2-3	• Partnerships • Education • Engagement	• Conservation plan implemented	• Sparsely vegetated lands 1
2.6: Address policy barriers that prohibit or discourage the voluntary creation or restoration of habitats and ecosystems by coordinating with local, State and federal agencies.	• Contra Costa County	• California Association of RCDs • State and federal representatives	• Phase 2	• Partnerships • Structural change • Funding	• X% increase in voluntary creation or restoration of habitats and ecosystems	• N/A
2.7: Explore the creation/expansion of tax incentives to conserve agricultural lands.	• Contra Costa County	• California Association of RCDs • State and federal representatives	• Phase 1	• Funding	• Tax incentives implemented to conserve agricultural land	• N/A
2.8: Implement the recommendations in the 2015 Contra Costa County Food System Analysis and Economic Strategy to protect agricultural areas at risk of development. Maintain and enforce the Urban Limit Line, encourage infill and transit oriented development, and adopt and implement policies, programs and projects to reduce urban sprawl and avoid land conversion.	• Contra Costa County	• Department of Conservation and Development	• Phase 1	• Partnerships • Funding • Structural change		• All NWL 8 • Forests/ Shrubland/ Chapparal 2 • Grasslands 1 • Sparsely Vegetated Lands 1

1. Acres of land restored target to be determined during restoration plan development.

MEASURE 3: Improve health of woodlands and mitigate wildfire ignition risk and fuel load in the wildland urban interface to reduce risk of wildfire events and resulting GHG emissions

TABLE 6. Actions for Improving Woodland Health and Mitigating Wildfire Risk

Action	Lead	Partners	Phase	Criteria	Performance Indicator	CARB Scoping Plan Strategies Covered (Appendix H)
3.1: Engage with the East Bay Regional Parks District, fire districts, fire safety organizations, MCE, CAL FIRE, local tribal groups, and other regional, local, and State agencies to conduct fuel treatments within their jurisdictions and along highway corridors, restoring ecosystem resilience and protecting communities through updates to the Community Wildfire Protection Plan.	• Fire Protection Districts • Firesafe Councils • RCD	• Contra Costa County Public Works Dept., and all other listed partners • Department of Conservation and Development	• Ongoing	• Partnership • Education • Engagement	• Collaborative groups engaged • Fuel treatments conducted	• Forests/ shrublands/ chaparral 1, 2, 3 • All NWL 1, 3, 7
3.2: Develop and implement a community education program to inform residents of the importance of clearing a defensible space around homes and resources available to residents. This may include tabling at community events, information resources on the County webpage, mailers, and social media.	• Fire Protection Districts County Coordinator	• RCD	• Ongoing	• Education • Engagement	• Community education program implemented	• All NWL 1, 3 • Developed lands 4
3.3: Seek funding from CAL FIRE Wildfire Prevention Grants Program to conduct fuel reduction projects, particularly in the wildland-urban interface.	• CCC Fire Protection District	• CAL FIRE • All CCC Fire Prevention District • County Coordinator • Firesafe Councils • RCD	• Ongoing	• Funding	• Number of wildfire prevention projects funded	• Forests/ Shrubland/ Chapparal 1
3.4: Implement shaded fuel breaks	• CCC Fire Protection District • Moraga-Orinda Fire Protection District	• CAL FIRE • East Bay Regional Park District • East Bay Municipal Utility District • All other fire protection districts and fire departments in CCC	• Ongoing	• Funding	• Number of shaded fuel breaks funded	

MEASURE 4: Protect the urban forest and increase urban tree cover

TABLE 7. Actions for Protecting the Urban Forest and Increasing Urban Tree Cover

Action	Lead	Partners	Phase	Criteria	Performance Indicator	CARB Scoping Plan Strategies Covered (Appendix H)
4.1: Develop and adopt a County Street Tree Policy which provides a guideline for the replacement of existing trees, designates suitable trees as replacements, and enables the County to partner with community groups to seek grants to sustain and nurture the County's urban forest.	• Contra Costa County Department of Conservation and Development	• Contra Costa RCD, Community groups • Contra Costa County Department of Public Works	• Phase 2	• Partnerships • Funding	• County Street Tree Policy Adopted • Tree replacement guidelines publicly available	• Developed lands 1, 2 • All NWL 1, 3, 9
4.2: Maintain and enforce the County Landscape Standards, which sets specific standards for planting and maintaining trees in the County, and Tree Protection and Preservation Ordinance which provides for the protection of certain protected trees in unincorporated areas of the County and prohibits removing trees on private property without a special permit.	• Contra Costa County Department of Conservation and Development	• Department of Public Works	• Phase 1	• Structural change	• County Landscape Standards and Tree Protection and Preservation Ordinance enforced	• Developed lands 1, 2
4.3: Develop an Urban Tree Plan to actively plant and maintain trees in unincorporated communities. The plan should aim to preserve and grow the County's urban tree canopy cover, for example through establishing a shade tree requirement for new development, especially in disadvantaged communities. Successful Urban Forest Management Plan development and implementation will depend on community engagement. **Step 1:** Draft and adopt an Urban Tree Plan with equitable community engagement **Step 2:** Implement the plan **Step 3:** Monitor and report on progress of the plan	• Contra Costa County Department of Conservation and Development	• Contra Costa Fire Protection District • Other County departments • Community members and community-based organizations	• Phase 1-3	• Equity • Education • Engagement	• Step 1: Urban Tree Plan completed • Step 2: Plan implemented • Step 3: X% increase in urban tree canopy to be set during plan development	• Developed lands 1, 2, 3 • All NWL 1, 2, 3, 9

Action	Lead	Partners	Phase	Criteria	Performance Indicator	CARB Scoping Plan Strategies Covered (Appendix H)
4.4: Plant new drought, fire-resistant tolerant trees at County facilities and parks following adoption of an Urban Tree Plan.	• Contra Costa County Department of Public Works	• Department of Conservation and Development • Others TBD	• Phase 3	• Partnerships • Funding • Structural change	• Number of additional trees planted at County facilities and parks	• Developed Lands 1

1. Urban tree canopy cover target to be determined during Urban Forest Management Plan development.

MEASURE 5: Facilitate mechanisms to value and fund local carbon sequestration projects

TABLE 8. Actions for Facilitating Funding for Carbon Sequestration Projects

Action	Lead	Partners	Phase	Criteria	Performance Indicator	CARB Scoping Plan Strategies Covered (Appendix H)
5.1: Identify costs and barriers associated with carbon offsets. Develop resources to provide assistance and increase participation from local land managers.	• Carbon Cycle Institute	• Contra Costa RCD • UCCE	• Phase 1-2	• Funding • Equity		• All NWL 10
5.2: Partner with the Contra Costa Resource Conservation District and other groups to develop and maintain an updated list of funding opportunities, resources, and application dates. Promote the CNRA Carbon Sequestration and Climate Resiliency Project Registry when it is launched in July of 2023.	• Contra Costa County Department of Conservation and Development	• Resource Conservation District • UCCE • NRCS	• Phase 1-3	• Funding • Partnerships • Education • Engagement	• Publicly accessible funding resources guide created and promoted	• All NWL 5, 7
5.3: Establish a budgeting framework for investing in local carbon sequestration projects to offset the balance of com-munitywide emissions by 2045 in line with County targets set in the County CAP and in compliance with State targets.	• Contra Costa County Department of Conservation and Development • County Administrator's Office	• Department of Conservation and Development	• Phase 1 or 2	• Funding • Structural Change	• Budgeting framework created and implemented	• N/A

6.

LOOKING AHEAD

INNOVATIVE AND EMERGING CLIMATE MITIGATION AREAS TO CONSIDER

Carbon sequestration is an imperative component to climate change mitigation efforts in California. Due to its relative novelty in efforts to combat climate change, the science continues to evolve; funding mechanisms become more readily available; and policy constantly advances. This section highlights some of the recent developments in these areas.

Emerging Science and Practices

Application of Crushed Basalt on Agricultural Soils

Initial research[23] on the application of recycled rock dust to farm and rangeland soils shows promise as a way to increase the rate at which carbon is stored in the soil. The tests were conducted in the laboratory, and additional in-field research to confirm the findings is currently underway, though initial results have been positive. Preliminary results show increased crop yield in plots with soil amendments added. Follow-up studies are needed to refine the understanding of potential co-benefits and impacts to soil characteristics, best practices for application, and practical methods for quantifying carbon sequestration under real-world conditions.

23. ***https://alumni.cornell.edu/article/cals-dean-ben-houlton-may-have-a-billion-ton-solution-to-climate-change***

Application of Biochar on Agricultural Soils

Biochar is the remaining residue after organic matter (trees, vegetation, food waste, etc.) undergoes heating or baking with limited oxygen in a process known as pyrolysis. Biochar application as a soil amendment has been suggested numerous times to the CDFA for inclusion under the Healthy Soils Program, and likewise to the NRCS for inclusion under EQIP. Biochar use as a soil amendment in agricultural settings has gained interest for its potential to increase water holding capacity, soil fertility, and carbon sequestration. A lack of readily available research and information on biochar usage prompted the development of the UC Davis Biochar Database, which exists as a resource for inputting and characterizing data from various approved peer and non-peer reviewed sources.[24] Biochar use is limited by its availability, as it is produced in very few locations, and many of the estimated GHG benefits are lost once the product is shipped over a certain distance. Still, with the exploration into new energy production technologies derived from biomass and the potential for biochar to be widely available, it is a management practice to further consider. Locally, the East Bay Regional Park District has acquired a carbonator and is working to remove biomass (dead/dying trees) from East Bay Parks for processing at the Anthony Chabot Regional Park. Similarly, the City of Brentwood recently entered into an agreement to manage wastewater in a new way that will create biochar as a byproduct.[25] Further investigation is needed as more local sources of biochar become available.

Funding Opportunities

There are numerous funding opportunities available in the state of California for projects that reduce GHG emissions and sequester carbon. These opportunities take the form of grants, loans, or market mechanisms, such as Cap and Trade programs. It should be noted that additional State and federal funding opportunities are developing; there may be opportunities in addition to the ones listed below, since the publication of this report.

Grants, Loans, and Other Funding Mechanisms

Carbon Sequestration and Climate Resiliency Project Registry: The CNRA is required by Senate Bill 27 (Skinner 2021) to create a registry intended to facilitate funding of nature-based and direct-air capture projects that deliver on California's climate goals by connecting listed projects with public and private sources of funds. The registry is scheduled for launch in July of 2023. There are two pathways for a project to be listed on the registry. Pathway A is for projects that meet CARB's minimum program requirements and that applied for but did not receive State funding. Pathway B is for projects that are approved through the registry's application process. Project requirements include:

- Achieves GHG reduction or carbon removal
- Includes monitoring and reporting
- Improves the state's climate resilience
- Documents 1) the amount of GHG reduction or carbon sequestered, 2) project location 3) resilience benefits, and 4) whether the project provides real, verifiable, quantifiable, additional, and permanent carbon removal benefits
- Projects shall not create carbon credits, or be used by a State or private entity to offset a statutory or regulatory obligation.

California Strategic Growth Council's SALC Program: Funds for this program are supported through the State's Cap and Trade auction. The SALC Program supports agricultural land conservation, economic growth, and sustainable development by providing grants for three types of projects: Land Use Planning grants, Agricultural Conservation Acquisition grants, and Capacity and Project Development grants. This report was funded through a SALC planning grant.

CARB Funding Agricultural Replacement Measures for Emission Reductions (FARMER Program): Local air districts receive funds based on a formula and award them to farmers and agricultural businesses for individual projects that reduce GHG emissions.

CDFA:

- Healthy Soils Program: Financial incentives for on-farm management practices that sequester carbon, including soil management, establishment of herbaceous and woody cover, and demonstration projects showcasing these practices. On-farm management practices that include, but are not limited to, cover cropping, no-till, reduced-till, mulching, compost application, and conservation plantings

24. *UC Davis. 2023. Biochar Database.* ***https://biochar.ucdavis.edu/about-us***

25 **https://www.thepress.net/news/brentwood/city-council-makes-changes-to-wastewater-treatment/article_7d1d6d4e-ae20-11ed-9696-c71f3e81ecf0.html**

- Conservation Agriculture Planning Grant Program: Funds carbon farm plan development

- **State Water Efficiency and Enhancement Program:** Funds energy efficiency upgrades for farm equipment, irrigation efficiency, etc.
- **Urban Agriculture Grant Program:** Funds urban farm support.
- **Climate Smart Agriculture Technical Assistance:** Funds technical assistance in the form of hands-on application assistance to farmers and ranchers participating in the Healthy Soils Program, the State Water Efficiency and Enhancement Program, and the Alternative Manure Management Program.
- **The California Infrastructure and Economic Development Bank's (IBank) Climate Catalyst Fund:** Provides low-interest loans for projects that deliver on priority actions to meet the State's climate goals, and where technologies and infrastructure exist that should be deployed at much greater speed and scale, yet face barriers in the private market.
- **CAL FIRE's California Forest Improvement Program:** Encourages private and public investment in California forest lands and resources, including management planning, tree purchase and planting, timber stand improvement, habitat improvement, and land conservation practices.

Carbon Offsets

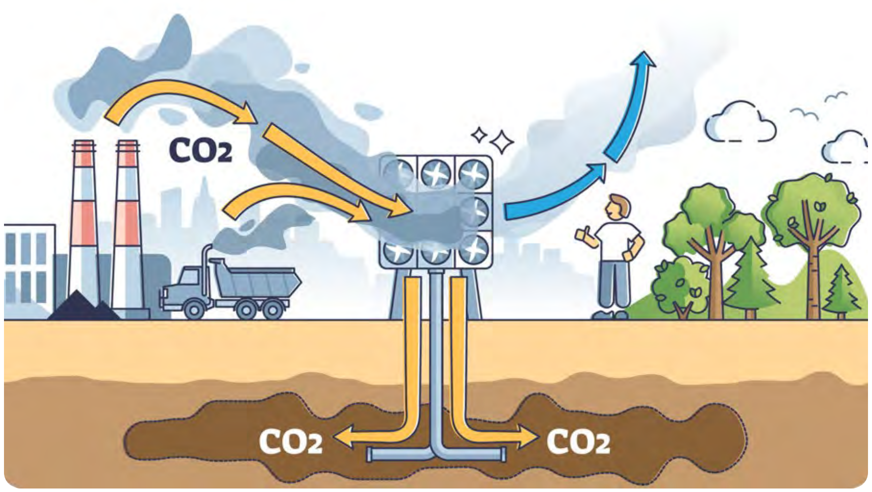
- **CDFW's Regional Conservation Investment Strategies Program:** Uses a science-based approach to identify habitat conservation and enhancement opportunities that can contribute to species adaptation to climate change and resiliency. These strategies can be used as a basis to provide advanced mitigation through the development of credits or to inform other conservation investments. California aims to make climate smart land management cost-effective through the implementation of market mechanisms.
  - California Cap and Trade Program (managed by CARB): The Cap and Trade program is one of the largest market mechanisms in the state. It establishes a declining limit on GHG emissions and creates a powerful economic incentive for investment in efforts that support GHG reductions and carbon neutrality. To meet its compliance obligations under the program, a regulated entity may use offsets from one of the six approved compliance offset protocols. These protocols include forestry, urban forestry, and rice-cultivation nature-based solutions. In addition to compliance offset projects, the Cap and Trade program also generates auction proceeds for the State, which have provided significant funding for nature-based solution projects.
  - Voluntary Carbon Market (CNRA): Allows regulated and non-regulated sources of GHG emissions to offset emissions through the purchase of credits derived from projects that support carbon neutrality. A team lead by the Sacramento San Joaquin Delta Conservancy has received approval by the American Carbon Registry on a voluntary market protocol that allows landowners to convert their land to managed wetlands or rice fields to stop subsidence and related carbon emissions. The team continues to work with landowners to convert lands.
  - Climate Action Reserve, Protocols for Carbon Offsets: The Climate Action Reserve is a carbon offset registry that sets the standards for offset protocols and has a voluntary program for creating carbon offsets. There are 19 protocols available for emissions-reductions activities in the United States, including urban forest, grassland, livestock manure, fertilizer management, rice cultivation, soil enrichment, and composting.
  - The Climate Action Reserve Climate Forward Program: The Carbon Project Registry issues credits ex ante, or before emissions-reductions projects are completed. This expands the scope and scale of carbon project types that can achieve carbon offsets by shifting the economics to help cover a portion or all of the project implementation costs. Forecasted mitigation units are issued to carbon mitigation projects that follow Reserve-approved methodologies. Climate Forward credits are issued about 1 year after project commencement for the forecasted climate benefit over the project's lifetime. These credits are well-suited for local projects and community-based measures and may be used to help create economic viability and offset costs associated with activities where costs are a primary barrier to implementation. There are currently methodologies for developing credits for six project types, including reforestation, mature forest management, and dairy digester installation. A methodology for Avoided Wildfire Emissions is currently under development and may provide much needed source of funding for wildfire mitigation projects.

Recently Adopted California Natural and Working Lands Legislation

As the California State Legislature continues to evolve and prioritize climate change and emissions reductions, Contra Costa County will be expected to stay in accordance with or ahead of the requirements. Though the following California State policies were drafted or adopted recently, and therefore did not directly impact this carbon feasibility report, they will become relevant in the coming months and years. The implications of these policies for the County are significant, in that they collectively require increased carbon sequestration efforts, reduced GHG emissions, and expanded preservation of natural lands.

SENATE BILL 905 CARBON SEQUESTRATION: Carbon Capture, Removal, Utilization, and Storage Program

This bill requires CARB to establish a Carbon Capture, Removal, Utilization, and Storage Program to evaluate the efficacy, safety, and viability of carbon capture, utilization, or storage technologies and CO_2 removal technologies. In carrying out the program's objectives, the bill would require the State board to prioritize, among other things, reducing the emissions of GHGs and reducing fossil fuel production in the state. This bill was adopted in September 2022.



ASSEMBLY BILL 1757 CALIFORNIA GLOBAL WARMING SOLUTIONS ACTION OF 2006: Climate Goal: NWLs

This bill would require the Natural Resources Agency, in collaboration with other specified entities, including CARB, to determine an ambitious range of targets for natural carbon sequestration, and for nature-based climate solutions, that reduce GHG emissions for 2030, 2038, and 2045 to support State goals to achieve carbon neutrality and foster climate adaptation and resilience. Targets must be set by January 1, 2024. The bill would require these targets to be integrated into the CARB scoping plan and other State policies. The bill will require an update of the NWLs Climate Smart Strategy to achieve these targets. Additionally, the bill requires the establishment of an expert advisory committee to inform and review modeling and analyses for NWLs, to advise State agencies on implementation strategies and standardized accounting, and to provide recommendations on addressing barriers to efficient implementation of the provisions of the bill. The bill would require the Natural Resources Agency to publish data on its internet website on progress made in achieving these targets, as specified.

This bill would require CARB to develop standard methods for state agencies to consistently track GHG emissions and reductions, carbon sequestration, and, where feasible and in consultation with the Natural Resources Agency and the Department of Food and Agriculture, additional benefits from NWLs over time no later than January 1, 2025. This bill was adopted in September 2022.

ASSEMBLY BILL 2278 NATURAL RESOURCES: Biodiversity and Conservation Report

This bill would require the Natural Resources Agency to implement actions to achieve the goal to conserve at least 30 percent of state lands and coastal waters by 2030, established by Executive Order No. N-82-20. The bill would require the Secretary of the Natural Resources Agency to prepare and submit, beginning on or before March 31, 2024, an annual report to the Legislature on the progress made during the prior calendar year toward achieving that goal, as provided. The bill would also make related findings and declarations. This bill was adopted in September 2022.

ASSEMBLY BILL 642 WILDFIRES

Amongst other directives, this bill requires the Director of Forestry and Fire Protection to appoint a Cultural Burning Liaison. The liaison will serve on the State Board of Fire Services to advise the Department of Forestry and Fire Protection on the development and expansion of cultural burning activity throughout the state. This bill also requires the department to actively engage Native American Tribes and cultural fire practitioners to enhance public education efforts on the restoration of cultural burning techniques and the importance of ecologically functional fire. Cultural burning practices have a long and storied history in California. One study suggests that prior to 1800, approximately 4.5 million acres of the state burned annually.[26] Unfortunately, much of the knowledge and expertise these practitioners possessed was lost as over a century of cultural and fire suppression made these practices illegal. This new legislation and recognition of the effectiveness of cultural burning techniques can allow a renewed expansion of prescribed fire led by California's Native American groups. A continued push to provide funding for education and public outreach will properly cement these practices as pivotal tools in the effort to reduce over a century of hazardous fuel loading in the wildlands. Many of the native Californian ecosystems are fire adapted, meaning they need occasional low-intensity fire as part of their reproductive cycle. Controlled burning techniques promote low-intensity fires at appropriate times of year when conflagration is unlikely. Controlled burning can be an effective way to reduce hazard fuels and rejuvenate the land. This bill was adopted in September 2021.

26. *Stephens, S., R. Martin, and N. Clinton. 2007. "Prehistoric fire area and emissions from California's forests, woodlands, shrublands, and grasslands." Forest Ecology and Management 251: 205–216.*

7.

CONCLUSION

This Carbon Sequestration Feasibility Study is one of the many proactive steps the County is taking to strategically manage land, reduce GHG emissions, and increase sustainability. This study is consistent with and complements the County's existing planning efforts and strategic partnerships, including the simultaneous update of the County General Plan and CAP. This study also supports the State's recommended approach to restore carbon in places where it has been lost and reduce large carbon losses on NWLs through active, attentive, and adaptive management.

The results of the analysis completed as part of this program indicates that over the last 20 years, the county's land use and vegetation has remained relatively consistent with a small decline in carbon stock mainly due to loss of shrubland and increasing development. As development in the county continues to grow to accommodate other State initiatives, such as expanded housing, the report analysis shows that the County still has ample opportunity to increase its carbon sequestration by employing the measures and actions in this report. For example, activities such as urban forestry, compost application to rangelands, alley cropping, and riparian restoration on grazing lands have the highest potential for carbon sequestration. Additionally, these activities have many co-benefits that improve quality of life and the environment such as improved socioeconomics, enhanced biodiversity, and water quality and quantity. When activities are stacked, or used in tandem, co-benefits are further increased.

The goal is for Contra Costa County and its partners to use this report study as a foundation to fund and successfully implement these climate smart practices. Even though challenges still exist in the form of regulatory barriers, cost of labor and maintenance, need for improved equipment, and obstacles to land ownership, the county has a robust network of individuals, community groups, non-profit organizations, and government agencies that are committed to maximizing the well-being of its residents and its NWLs. This network of dedicated individuals, accompanied by an unprecedented amount of guidance and financial resources from the State, put Contra Costa County in an optimal position for maintaining resilient NWLs in the county and setting an example for other counties in the state.

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Appendix A

Carbon Farm Plans

Urban Farm #1
CARBON FARM PLAN

August 2022

CONTRA
COSTA
RESOURCE
CONSERVATION
DISTRICT

This carbon farm plan was prepared by staff at the Contra Costa Resource Conservation District between March and August of 2022. For more information about this plan or questions, please contact Contra Costa Resource Conservation District.
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This carbon farm plan was developed as part of the Contra Costa County Department of Conservation and Development's "Healthy Lands, Healthy People" grant, funded by the California Department of Conservation's 2020 Sustainable Agricultural Lands Conservation (SALC) Grant Program. Contra Costa Resource Conservation District wishes to thank both the Contra Costa County Department of Conservation and Development and the California Department of Conservation for their funding and support to develop this carbon farm plan.

Contra Costa Resource Conservation District would also like to thank the University of California, Cooperative Extension Contra Costa Office for their support in carbon farm planning and in editing this plan.

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Introduction

Carbon is the basis for all agricultural production, and yet has largely been absent from discussions of elements essential for agriculture and the management of working lands. Carbon enters farm systems from the atmosphere through photosynthesis by plants, which uses the energy of sunlight to capture carbon dioxide (CO_2) from the air and combine it with water and nutrients from soil to produce agricultural products: food, fiber, fuel and flora. Furthermore, photosynthates (sugars) produced by plants are moved to the soil directly as exudates from plant roots and from the soil surface through litter from plant parts such as leaves and stems. These feed soil mycorrhizae, thus adding additional carbon to the soil. Another pathway for added soil carbon is through compost and other organic amendments like manure from animals.

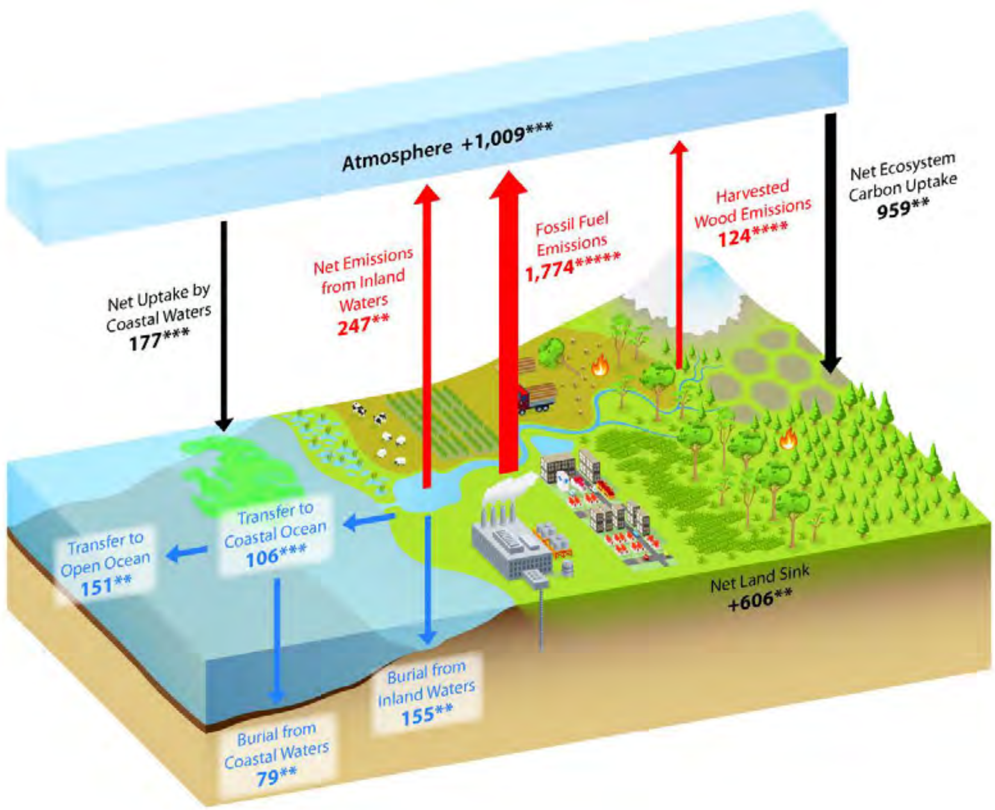

Figure 1. The Carbon Cycle, as modeled by the US Carbon Cycle Science Program.

In addition to its transformation from CO_2 into the sugars, cellulose and lignin of the harvestable crop, carbon can also be beneficially stored long-term (decades to centuries or more) in soils and woody vegetation in a process known as terrestrial carbon sequestration. While the importance of carbon to soil health and fertility has long been understood, its significance in the context of climate change has been increasingly recognized in recent years. Today, land management for increased soil organic matter, which is about 50% carbon, is the core of the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) healthy soils program and the California Department of Food and Agriculture's 2015 Healthy Soils Initiative.

Carbon Farm Planning is the process of identifying opportunities to decrease the production of greenhouse gas on-farm and increase the photosynthetically driven transfer of atmospheric CO_2 to stored carbohydrates in soils and above and below ground biomass. Enhancing working land carbon, whether in plants or soils, results in beneficial changes in a wide array of system attributes including: soil water holding capacity, soil hydrological function, biodiversity, soil fertility, agricultural productivity, as well as resilience to drought and flood. Increasing carbon capture on working lands also helps slow rising levels of CO_2 and other greenhouse gasses in the atmosphere, currently contributing to climate destabilization and unpredictability through global warming.

Carbon Farming

Technically, all farming is "carbon farming," because all agricultural production depends on the photosynthetic process of moving CO_2 out of the atmosphere and into the plant where it is transformed into agricultural products, whether food, flora, fuel or fiber. Atmospheric carbon entering the farm can end up in several locations: the harvested portion of the crop; the standing crop carbon stocks (grassland vegetation, vines and orchards, etc.); the soil as root exudates; the soil organic matter from "waste" materials (compost or manure); or as other permanent woody or herbaceous vegetation (windbreaks, vegetated filter strips, forests and woodlands). While all farming is completely dependent upon carbon, the various farming practices, and the different farm systems, can lead to variable amounts of on-farm carbon capture and storage. The carbon farm planning process differs from other approaches to land use planning by focusing on increasing the capacity of the working farm or ranch to capture carbon and to store it beneficially in the crop, in the standing carbon stocks, and/or in the soil.

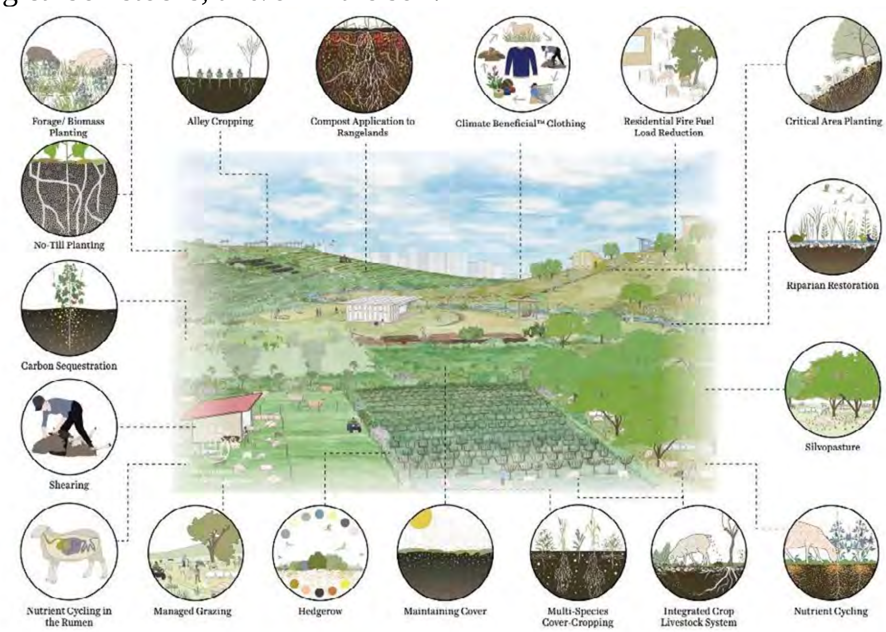

Figure 2. Carbon farming practices, courtesy of Fibershed.

While agricultural practices often lead to a gradual loss of carbon from the farm system, particularly from working land soils, carbon farm planning is successful when it leads to a net increase in farm-system carbon. By increasing the amount of photosynthetically captured carbon stored, or "sequestered," in long-term carbon pools on the farm or ranch, carbon farming can result in a direct reduction in the amount of CO_2 in the atmosphere, while supporting crop production and farm resilience to environmental stress, including flood and drought.

On-farm carbon in all its forms (soil organic matter, perennial and annual herbaceous vegetation, plant roots, root exudates and standing woody biomass), contains energy, which originated as the solar energy used by the plant to synthesize carbohydrates from atmospheric CO_2 and water and nutrients from the soil. The carbon in plants and soil organic matter can thus be understood as converted solar energy that enhances on-farm processes. Farming is still viable in low soil organic matter operations, as evidenced by current conventional, but there are long-term concerns about sustainability and viability of farms as soil organic matter drops. Increased soil organic matter increases soil water holding capacity and nutrient capture, which further enhances plants, and their outputs. With that understanding, carbon farm planning places carbon at the center of the planning process, looking at on-farm resource issues through solutions that also increase carbon sequestration.

The Carbon Farm Planning Process

Carbon farm planning is based upon the USDA NRCS Conservation Planning process. The USDA NRCS Conservation Planning process is a natural resource problem solving and management activity that integrates economic, social, and ecological considerations to meet private and public needs on a farm or ranch (USDA NRCS, 2022). The end goal aims to improve natural resource management, minimize conflict, and address problems and opportunities. Carbon farm planning utilizes that same framework, but incorporates an additional lens of carbon sequestration as another natural resource issue. This simplifies the planning process and connects on-farm practices directly with ecosystem processes, including climate change mitigation and increases in: on-farm climate resilience, water holding capacity, soil health and agricultural productivity.

Similar to NRCS Conservation Planning, carbon farm planning begins with an overall inventory of natural resource conditions on the farm or ranch, but carbon farm planning focuses on identifying opportunities for reduction of greenhouse gas emissions and enhanced carbon capture and storage by both plants and soils. Building this list of opportunities is a brainstorming process that aims to be as extensive as possible, including everything the farmer and planners can think of to potentially reduce emissions, capture and sequester on the farm, while also balancing food and farm production. While actions proposed in the carbon farm planning should reflect the inherent limits of the farm ecosystem, financial considerations should not limit this initial brainstorming process, as one goal of the carbon farm planning process is to identify potential funding, above and beyond existing resources, to realize implementation of the carbon farm planning. Soil erosion or water quality issues, for example, are addressed in the plans by recognizing the carbon capture opportunities associated with addressing these resource concerns. It is the premise of the carbon farm planning process that these resource concerns arise due to a failure to recognize the central role of carbon in the farm or ranch system, and that by addressing system carbon capture potential, virtually all other resource concerns will be addressed.

Photo 1. Carbon farm planning on the [redacted] *row crops, photo by Ben Weise*

During this process, a map or maps of the farm are developed to show existing farm infrastructure and natural resource conditions. These maps are used to locate potential carbon capture practices on the farm and to envision how the farm may be expected to look years down the road, following plan implementation. In the context of [redacted] planners looked to future planned buildouts of the [redacted] to inform what management practices could be implemented in the years to come.

Next, the carbon benefits of each practice, as potentially applied at the farm scale, are quantified using the online USDA greenhouse gas model, COMET-Farm (cometfarm.nrel.colostate.edu), COMET-Planner, (comet-planner.com), the CDFA Designed COMET-Planner (http://comet-planner-cdfahsp.com/) or similar tools and data sources, in order to estimate metric tons of carbon dioxide equivalent (CO_2e) that would be 1) avoided, or 2) removed from the atmosphere and sequestered on farm by implementing the identified conservation practices. A site-specific list of potential practices and their on-farm and climate mitigation benefits is then developed.

Economic considerations may be used to filter the comprehensive list of practices, and funding mechanisms are identified, including: cap and trade, CEQA mitigation, or other greenhouse gas mitigation offset credits, USDA-NRCS and/or other state and federal programs, and private funds. Practices are implemented as funding, technical assistance and farm scheduling allow. Over time, the carbon farm planning is evaluated, updated, and altered as needed to meet changing farm objectives and implementation opportunities. The fully implemented plan scenario is the ultimate goal or point of reference. Where plan implementation is linked to carbon markets or other ecosystem service markets, periodic Plan evaluation may be tied to those verification or monitoring schedules. Additional information about Carbon Farming is online at: www.marincarbonproject.org and www.carboncycle.org

[redacted]

In Summer 2021, the Contra Costa County Department of Conservation and Development applied to the Department of Conservation's Sustainable Agricultural Lands Conservation Grant Program in partnership with the University of California, Cooperative Extension and the Contra Costa Resource Conservation District to investigate carbon sequestration potential opportunities within Contra Costa County. Under that grant, Contra Costa Resource Conservation District received funding to write and develop the first Urban Farm Carbon Farm Plan in California with [redacted] first expressed interest in carbon farm planning in 2018 and has developed their farm with climate-smart agricultural practices in mind since beginning the farm in 2014. As a participant in the Carbon Farm program, [redacted] has agreed to an ongoing partnership with the Contra Costa Resource Conservation District through carbon farm assessment, planning and implementation phases. The project will include monitoring and adaptive management to meet landowner and carbon farm planning goals from the implementation phase and beyond.

Farm Location

[redacted] is a non-profit with a mission of inspiring, hiring, and training local residents to cultivate agriculture, feed their community, and restore relationships to land to build a more sustainable food system within a just and healthier community ([redacted] 2022). [redacted] manages a number of sites ranging from public parks and green spaces, to school and community gardens, and includes an urban farm located in [redacted] [redacted] in Western Contra Costa county at [redacted] This Carbon Farm Plan is developed for the [redacted] a 3.1-acre urban farm on the outskirts of [redacted] CA.

History of [redacted]

[redacted] began operating on the site in August 2014 and immediately got to work improving the site and soil conditions to facilitate urban farming in the future. Prior to [redacted] working on the site, the site changed ownership numerous times and laid vacant on the periphery of [redacted] CA.

Tribal Recognition and Land Acknowledgement

[redacted] is currently headquartered at the [redacted] which sits on land historically managed by the Confederated Villages of Lisjan as well as the Chochenyo, Karkin, and Muwekma Ohlone Tribes prior to their being driven out and killed by colonizers and missionaries. [redacted] recognizes this past and is working toward a better future. In collaboration with these tribes, their aim is to restore the land and establish culturally relevant programming at the [redacted] and other sites (Native Land Digital, 2022).

Black Cowboys

Years before [redacted] managed the land that is now [redacted] the property comprised a horse corral and riding circle. In the early 1970s, the [redacted] site was formerly used by the Black Cowboys to keep their horses and other equipment. As an entity, the Black Cowboys aim to educate the wider public on the important role that African-Americans played in ranching. By some estimates ,at the height of the ranching era in the United States, one-quarter to one-third of cowboys were African-American (Nodjimbadem, 2017). The Black Cowboys aim to bring awareness to this history and of the contributions African-Americans made and are still making to ranching and animal husbandry.

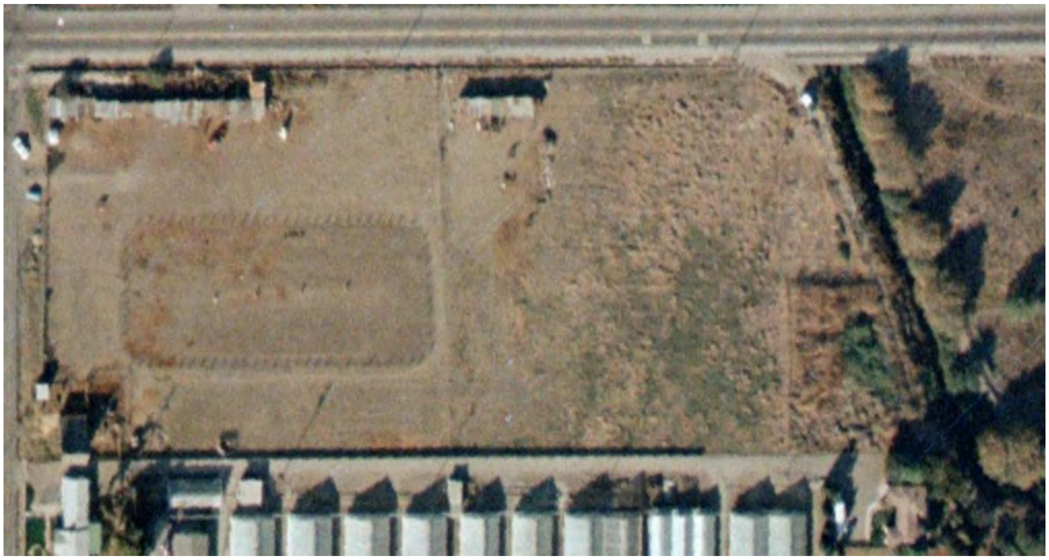

Figure 3. Aerial Photo from 1974 showing riding circle and corral, provided by [redacted]

Prior Agricultural Use

While historical records are sparse, [redacted] has been used for agriculture by a number of Italian, Asian, and Portuguese immigrants to grow vegetables and other produce. With the dawn of World War II, a number of Black workers from Louisiana and other parts of the South came to [redacted] and the Bay seeking jobs in the growing shipbuilding industry. As a result of redlining and other racist laws, many people of color were locked out of housing in [redacted] and turned to surrounding areas, including [redacted]

Following the end of World War II, many Japanese families returned from internment camps to their houses and cut flower enterprises throughout the Bay Area to find them vandalized or in some cases destroyed. Many then turned to [redacted] and tried to rebuild what was once a thriving cut flower industry. (Garrison, 2022)

Current Land Use Trends

Today, [redacted] is entirely zoned as P-1 Planned Unit District (Contra Costa County, 2022), “intended to allow diversification in the relationship of various uses, buildings, structures, lot sizes, and open space while ensuring substantial compliance with the general plan and the intent of the county code.” This relatively open land-use zoning allows a variety of land uses within its sphere, which is evident upon visiting the [redacted] Directly west of the farm is a business providing ready-mix concrete, recycled rock, and other products. Southwest of the farm is a private sanitation company that serves nearby cities. South of the farm is currently a vacant lot slated to be warehouses for shipping and fulfillment centers. East of the farm is the site of former cut-flower greenhouses. North of the farm is San Pablo Creek and a storage facility for construction equipment and tools. Thus, land use is multi-faceted around the North [redacted]

Farm. At present, much of the area is being sold for development to shipping and fulfillment centers whose proposed structures present significant obstacles, including substantial shading of the [redacted] is currently working to stop this development through a variety of strategies.

Map 1. [redacted] Surrounding Area and Land Use

Ownership by [redacted]

After renting the land from the Contra Costa County government, [redacted] purchased the land outright in September 2021 and now owns the 3.1-acre parcel at [redacted] is currently in a capital campaign to improve the site with numerous plans for an Ohlone Reflection Garden, a kitchen to process and create value added products, office space for farm staff, and a number of other amenities that will allow them to thrive and provide good, healthy food to the people of [redacted] and the East Bay ([redacted] 2021).

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Existing Environmental Conditions

[redacted] is located on the periphery of [redacted] CA in unincorporated western Contra Costa County in the East Bay area of the San Francisco Bay Area.

Weather and Climate

Like the rest of California, [redacted] experiences a Mediterranean climate with hotter and longer summers and warmer short winters. Given the unique geography of the San Francisco Bay Area, there are a number of pockets and micro-climates throughout the region. With its proximity to the San Francisco Bay, [redacted] is typically cooler than the rest of Contra Costa County, receives more precipitation (almost entirely rain, but some historical records of snow), and receives fewer sunshine days as a result of fog. The average annual temperature is around 66 degrees with an average max temperature of 74 degrees in September and average minimum temperature of 42 degrees in January. Historical records suggest an average precipitation of 23 inches, but that is likely to decrease as a result of climate change and prolonged drought in the American West (Western Regional Climate Center, 2022).

Map 2. [redacted] *and proximity to Wildcat and San Pablo Creeks*

Sensitive Environmental Areas

The [redacted] is located at [redacted] in [redacted] CA in a fairly urban environment on the fringes of [redacted] CA. The farm is surrounded by [redacted] to the west, [redacted] to the south, former cut flower greenhouses to the east, and the San Pablo Creek to the north.

San Pablo Creek is managed by the Contra Costa Flood Control and Water Conservation District with assistance from [redacted] Under this program, west Contra Costa County residents are taught skills and given opportunities to care for their watersheds, communities, and the creeks that run through them.

The main tributary of San Pablo Creek runs for approximately 18-miles through [redacted] El Cerrito, and El Sobrante in western Contra Costa County. The creek's headwaters are located in the hills above [redacted] These headwaters have been dammed to create the San Pablo Dam and Reservoir which supplies drinking water to customers of the East Bay Municipal Utilities District. The San Pablo Creek watershed is approximately 41 square miles and includes near-pristine oak woodlands in the upper reaches of the watershed to suburbanized and urbanized lands in the lower stretches. (Owens-Viani, 2000)

At the [redacted] the San Pablo Creek is a healthy riparian channel approximately 1.25 miles upstream from the San Pablo Bay and San Francisco Bay. The Contra Costa County Flood Control and Water Conservation District does periodic work along the levees around the creek to protect residents from flooding creek waters. This last occurred in Fall 2017 directly west of the [redacted] on the neighboring property.

Generally speaking, San Pablo Creek is a healthy creek and watershed in [redacted] CA that flows semi-naturally but is now constrained by development and urban environments. The cities of [redacted] El Cerrito, and El Sobrante grew around the creek, preserving the natural meander that is characteristic of creeks and rivers. Over time, development along the creek has forced it into its present formation with a number of riffles, sand bars, and other structures along the entire creek that provide habitat for many birds, amphibians, and fish, including spawning steelhead.

Water

In October 2020, a permanent irrigation system was installed which allowed [redacted] to convert from hand-watering via hose to drip irrigation. Previously, water was pulled from other parts of the property by hose and applied to the plants. The new drip irrigation system has been designed to allow for additional irrigation lines should the farm seek to expand. Water is provided by the East Bay Municipal Utility District (EBMUD) at municipal water prices.

Soil

The USDA Natural Resources Conservation Service (NRCS) surveyed the soils of Contra Costa County in 1977 and then again in 1987 (USDA NRCS, 2022). It is assumed that given the lack of substantial development (buildings, etc.) and that without testing that the soil surveys are still representative and haven't substantially changed since 1987. The soil survey found two significant soil types within the [redacted]

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Table 1. Soils from [redacted] Parcel

Map Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BaA	Botella clay loam, 0 to 2 percent slopes, MLRA 14	2.5	80.3%
So	Sycamore silty clay loam, 0 to 2 percent slopes, MLRA 17	0.6	19.7%
Totals for Area of Interest		**3.1**	**100.0%**

Map 3. Soils Map for [redacted] from NRCS Web Soil Survey. Report is included in Appendix.

BaA – Botella clay loam, 0 to 2 percent slopes

The Botella clay loam component is the dominant soil type at the [redacted] accounting for over 80% of the 2.5-acre parcel. The Botella series consists of very deep, well-drained soils formed from alluvial material from sedimentary rocks in the upper watershed. These sedimentary rocks are found typically in valley bottoms and alluvial fans which is consistent given the proximity of both San Pablo Creek and Wildcat Creek (California Soil Resource Lab, 2022).

This soil typically has a high organic matter content at around 4% in the first 25 cm before dropping to 1.25% from 26 cm to 175 cm. Given the high organic content and the drainage potential of the soils, this soil is rated Grade 1 – Excellent by the California Revised Storie Index. All vegetable rows and orchard trees on the [redacted] are planted within this soil.

So – Sycamore silty clay loam, 0 to 2 percent slopes

The Sycamore series is another large soil type within the area that only partially covers the [redacted] accounting for approximately 0.6-acres or 20% of the parcel. These soils are not as well-draining as the Botella series mentioned previously but can still support non-rice agriculture well enough. This soil series is typically found on nearly level flood plains at low elevations and formed in mixed sedimentary alluvium under poorly drained conditions.

This soil has fairly shallow organic matter content, observed at 2.5% for the first 10 cm before dropping below 1% at 55 cm and below 0.5% at 100 cm. While it has a lower soil organic matter content, it is still suitable for agriculture and is commonly found along the flood plain of the Sacramento River. Under the California Revised Storie Index for Agriculture Suitability, it received a Grade 3 – Fair, mostly as a result of its poor drainage. Current conceptual designs for the [redacted] show that the Ohlone Reflection Garden and Main Barn/Farm Stand/Wash & Pack buildings will be located on this soil series, with little to any active agriculture occurring.

[redacted] Soil Testing

[redacted] staff followed up with soil testing in 2018 for heavy metals, and then again in 2021 for more generalized soil health. The 2018 Soil Testing was performed by PhD students from the Department of Environmental Science, Policy and Management at UC Berkeley. The conclusions are included below, and the full report is included within the appendix.

Conclusions and recommendations:

- *Add large quantities of organic matter: Adding organic matter (manure, compost, cover crops, mulch, etc.) will dilute contaminants and make them less bioavailable and increase the microbial life that breaks down organic contaminants over time. Adding soil organic matter also increases nutrient content and water holding capacity while decreasing compaction, creating higher quality agricultural soils.*
- *Remove asphalt to the extent possible: Remove asphalt fragments found in production space soil and grow food crops in soil with lower amounts of visible asphalt.*
- *We consider this soil to be suitable for agricultural production if these recommendations are followed, and expect to see a reduction of organic contaminants as the soil management plan is implemented. Follow up testing will be completed at a later date.*

In 2021, [redacted] staff collected their own soil samples and sent them to Soil Control Lab, a private business in Watsonville, CA. [redacted] sent 4 samples (Row Crops 1st Set, Row Crops

2nd Set, Orchard, and Orchard Root Zone). These soil reports are also included in the appendix. The results largely suggest that the Row Crop areas are good with high organic content, accounting for 31-32% of the sample provided, largely as a result of the composting, cover cropping, and soil building practices [redacted] implemented at the [redacted] Within the orchard and orchard root zone, many components of the soil were rated "low" or "okay"; the observed organic matter was much smaller, but still high at 8%. On the whole, this is explained by [redacted] management of the row crops and soil building practices, applying compost, cover crops, and mulch in frequent quantities. Orchard systems tend to be more stable and don't require the high levels or organic matter that row crops typically do. Still, the organic matter content, while still high at 8%, can be improved within the orchard through better weed management that may be stealing nutrients, water, and carbon from the trees.

Roughly comparing like values between the 1987 Soil Survey and the 2021 Soil Sample showed that by and large, the soil survey is still representative save for the organic matter percentages. The 2021 samples showed SOM at around 30% at 15 cm while the 1987 Survey estimates ~4% at the same depth. Again, this is evidenced by [redacted] early work in adding compost, mulch, and other soil building practices that relies on high organic matter input into the soil.

Vegetation

Creek Vegetation, Invasive Weeds

The [redacted] is primarily cultivated, but still feels invasive weed pressure from both the seed bank and the edges of the farm.

To the north, the San Pablo Creek vegetation is mostly native with some invasive weed pressure. During the site visit in April 2022, CCRCD staff observed common invasive weeds like poison hemlock (*Conium maculatum*) and Himalayan blackberry (*Rubus armeniacus*), as well as native vegetation like *Salix* spp., *Populus* spp., and other native riparian plants. [redacted] works with the Contra Costa Flood Control and Water Conservation District to manage this reach and other reaches of San Pablo Creek.

Left unchecked, Himalayan blackberry has the potential to engulf the site and shade out native low-lying riparian shrubs that provide habitat for birds, bees, and butterflies. Himalayan blackberry was also observed along the fence line and is currently acting as a hedge. Careful maintenance is required to manage the blackberry so that it does not invade the [redacted] further. Competitive plantings are available and part of a broader invasive pest management strategy to stop the Himalayan blackberry and promote other beneficial hedgerow plants.

The row crop areas were relatively clean and weed free, allowing for easy access to any production plant within the rows. Continued maintenance is needed to ensure these stay weed free, but there is enough activity (i.e., maintenance) on the rows to catch and eliminate invasive weeds within these areas.

Invasive weeds were most present within the orchard. While visiting the site, carbon farm planners speculated that the weed growth may be hindering growth of the orchard, given the veracity of their growth and height, and the relative low height of the orchard plantings. Planners speculated that the weeds may be taking up nutrients and water at the expense of the orchard trees. During the site visit, weeds were observed between the trees at an estimated height of 2' to 3'. Current management of the weeds relies on string trimmers. When the trees were initially planted,

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mulch and wood chips were placed around the base of the tree along with cardboard that would degrade into the soil and provide carbon. In other parts, [redacted] installed a cover crop from seed including red clover which was observed. Vegetative cover on orchard floors is a recommended practice and will help sequester atmospheric carbon while also promoting soil and tree health, but careful attention should be paid to what species that vegetative cover is (cover crop vs. invasive weed) and managed so as to divert resources to production agriculture (fruit) instead of invasive weed cover.

Photo 2. [redacted] *aerial map, pictured in June 2021 by Google Earth.*

Current Land Use

Ownership

[redacted] acquired the site from the Contra Costa County government in Fall 2021 and has been managing the site since 2014. Under the new ownership, [redacted] expects to build out on the site (see Site Plan below) and install permanent urban farm infrastructure to facilitate better farm stewardship and management.

Site Plan

Currently, [redacted] operates the [redacted] on a 3.1-acre parcel that is also the organization's main office. After beginning work on the property in 2014, [redacted] began

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improving soil health and soil organic material by implementing a number of soil building exercises including compost application and soil amendments.

Today, the [redacted] ultimately consists of a number of vegetable rows that grow over 40 varieties of seasonally appropriate vegetables, a young orchard containing a diverse array of fruits, a chicken coop, and greenhouses/high tunnels for seedlings and plant propagation. The [redacted] also contains a number of farm infrastructure pieces, namely washing and packing tents, farm offices, and windrows of compost being created for use on the farm.

The [redacted] is also under construction as [redacted] builds out their vision for the site, a community space in North [redacted] that will provide healthy fresh food to the local community, value added products from their fruits and vegetables, classrooms to teach sustainability, watershed stewardship and cooking, and a reflection garden to honor the Native American tribes that utilized this space long before [redacted] was on the site.

[redacted]

Figure 4. [redacted] *Phasing Site Plan*

Row Crops

The [redacted] contains approximately 0.5-acres of row crop vegetables and flowers in rows created by [redacted] [redacted] staff reported that over the course of a year, approximately 47 varieties of vegetable crop are transitioned through the rows including a variety of leafy greens, beets, lettuces, potatoes, herbs, tomatoes, berries, squash, garlic, kale, and much more. The farm currently practices reduced tillage and is aiming for no tillage on the rows. As a practice, [redacted] tries to maintain vegetative cover when and where appropriate, cutting the tops of plants and leaving root matter to decay and break down in the soil. Mulch has also been applied at some point to a majority of the rows.

With regard to the rotation, [redacted] collective members report always following tomatoes with a cover crop as a means of keeping the soil clean, but as a result there is really no rest period for the soil. Cover crops are terminated by being incorporated into the soil. All of these management practices are done by hand, by farm collective members or by volunteers at [redacted] This 0.5 acre sustains a year-round community supported agriculture program run by [redacted] that provides free or reduced food to residents of [redacted] San Pablo, and El Cerrito. [redacted] plans to expand this production area in the years to come.

Orchard

In 2016, [redacted] installed an orchard on the western edge of the property to supplement their community supported agriculture program with fresh fruits. The orchard is diverse and contains a number of varieties including apricots, persimmons, apples, pears, lemons, and oranges. Like the row crop system, [redacted] hopes to expand the size of the orchard in the coming years.

Photo 3. Volunteers planting trees in the orchard for MLK Day of Service, 2022. Photo by [redacted]

Chickens

On the north side of the property, [redacted] keeps a chicken coop and a number of chickens for egg production to supplement their community supported agriculture boxes. The chickens are confined to the coop, but [redacted] has expressed interest in using the chickens to control weeds and pests around the farm in a "chicken mower".

[redacted] **Bees**

[redacted] also manages a couple of honey bee boxes to help pollinate their crops and provide habitat for bees and other pollinators. Within the site, [redacted] has planted cover crops including red clover for bee forage, and has a number of flowering pollinator friendly plants acting as hedgerows for the farm and habitat for the bees. The honey is processed and sold or incorporated into the community supported agriculture boxes.

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[redacted] Watershed Apprentices

[redacted] operates the [redacted] program which aims to provide West County residents with skills and opportunities to care for their watersheds, communities, and the creeks running through them. This program operates through Western Contra Costa county, but is and will be headquartered on the northern part of the [redacted]

[redacted] Compost Trials

[redacted] has experimented with various compost creation and application trials across the property. During the site visit in Spring 2022, we toured established windrows that [redacted] was using to make compost. According to plan designs, there will be future compost creation areas on the farm, but on a much smaller scale in order to facilitate more production agriculture across the farm.

Neighboring Land Uses

Given its location in [redacted] and the open zoning code, the [redacted] is surrounded by a variety of different land uses ranging from sites of prior greenhouse agriculture, construction equipment storage and maintenance sites, commercial office buildings, and landfills/construction material sales. As of the writing of this plan, [redacted] is engaged in an effort to preserve their [redacted] and prevent it from being shaded out by potential shipping and fulfillment center warehouses on neighboring property to the east and south. The land use will very likely continue to be mixed in the future.

Resource Issues, Goals and Objectives

During the site visit and in follow-up email communications, [redacted] staff expressed two major resource issues they want to address on site.

Issues

Ponding within Row Crops

[redacted] reported that part of the western row crop fields is prone to flooding and ponding following heavy rains. Historical aerial imagery via Google Earth identifies a small area within the property that appears to be a different color, or soil type that could potentially be the culprit. While it is unclear what is causing the ponding, it is suspected that a hardpan may have developed given the history of grazing and horses on the property.


Map 4. The [redacted] *prior to* [redacted] *site management (2003) and under* [redacted] *Management (2021). The drawn blue line is reported ponding area.*

Compost Application, Groundwater Leeching, and Runoff

In personal communication via email with [redacted] staff, CCRCD staff were informed that [redacted] staff "were concerned that compost amendment practices may be threatening the creek and possible the groundwater." As is later discussed in the Climate Smart Practice chapter, [redacted] staff turn compost into the row crop beds after a growing cycle if the bed is not rested to provide valuable nutrients for the next crop to go in the ground. [redacted] staff further inquired about using blood meal and/or fish emulsion fertilizers as a means to prevent leeching into San Pablo Creek.

Goals and Objectives

Through the development of this Carbon Farm Plan, the landowner identified on-farm resource issues, and long-term farm goals.

Soil Health

Following initial soil testing (discussed previously in the Soil section, full results are included in the Appendix) of the site when [redacted] began working at the [redacted] a group of researchers from UC Berkeley recommended, and [redacted] subsequently adopted, a suite of goals to aspire to including:

- Adding and increasing organic matter for soil health, plant health, and soil remediation
- Continued removal of asphalt from site and from within soil as appropriate
- Monitoring of polycyclic aromatic hydrocarbons, a contamination as a result of the asphalt within the soil
- Continue soil management practices to build soil organic matter while breaking through hardpan

Water

While not explicitly discussed, [redacted] has a goal of reducing their water use and being more efficient with their water to manage their production agriculture. With the installation of a water meter and drip irrigation systems, [redacted] should meet this goal, but may find with increased soil health and climate-smart agriculture installation that the soil water holding capacity of the soil increases and water use is decreased.

In communications following the site visit, [redacted] staff identified one goal to monitor water quality above and below the [redacted] to better understand and manage compost additions and leaching into the San Pablo Creek.

Air Quality

[redacted] is already implementing a number of beneficial climate-smart management practices that are sequestering carbon into the soil. This carbon farm planning effort looks to quantify existing sequestration practices, and identify other practices that may sequester additional carbon. Improving air quality in general is another significant goal of [redacted] and something they both aim to do at their site and through advocacy work in the larger [redacted] and western Contra Costa area.

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Climate Smart Practices

Existing Climate Smart Practices

[redacted] currently practices a number of climate-smart agricultural practices with the goal of improving soil quality, improving air quality, and continuing to build a sustainable urban farm operation in North [redacted] Below is a brief sampling of observed and discussed practices from the April 2022 site visit.

Cover Cropping

[redacted] staff reported using cover crops to build soil within the row crop systems and keep the soil covered. The cover cropping window is limited however (December to January), as [redacted] aims to have seasonal fruit and vegetable production year to fulfill CSA boxes and provide year round food support to their community.

Within the orchard, [redacted] has also utilized cover cropping, and RCD Staff observed some seeded clover areas within the orchard, but the cover crop in the orchard has largely failed as a result of weed pressure. Still, weeds can offer similar benefits of cover cropping.

Photo 4. Red clover, California poppy, and other grasses and weeds acting as a cover crop in the orchard on the [redacted] photo by Ben Weise.

Hedgerows

[redacted] uses hedgerows to attract pollinators into the orchard and into the row crop systems. Within the row crop systems, at the end of each row is a pollinator plant or native plant of many different varieties. Some rows were also seeded with native wildflowers. While these are great for pollinators, CCRCD recommends installing a more permanent hedgerow that will continue to attract pollinators, and provide habitat for birds and other pollinating animals. [redacted] Staff planted a hedgerow on the western edge of the property along the fence line where staff observed *Ceanothus spp.*, *Erigonum fasciculatum* and other native hedge species on the boundary of the orchard.

Photo 5. Wildflower hedgerow on the edge of the row crop fields at the [redacted] *photo by Ben Weise.*

Mulching

[redacted] staff reported adding mulch to every row in the row crop system except for three rows. It was assumed that this is done annually as part of an effort to build soil health, retain water, and promote plant health.

Photo 6. Compost windrows at the [redacted] photo by Ben Weise.

<u>Compost</u>

During the site visit, [redacted] described their composting process as another way to build soil within the row crop systems. Through the windrow composting process, [redacted] is creating compost on site from plant matter, pulp, and straw. The rows are aerated (turned) to create the compost where it is eventually incorporated into the soil. The composting process does not include worms, but [redacted] does maintain a worm bin on site. [redacted] has not tested their compost to determine actual compost chemical content, but with higher inputs of plant material, pulp, and straw, CCRCD Staff assumed that this is a higher carbon content compost (C:N >11). CCRCD staff also inquired about application rates and [redacted] Staff reported that their current, small, three-bin composting system generates approximately 15 wheelbarrows of compost material or approximately 90 cubic feet, or approximately 3.3 cubic yards. With an average one cubic yard of wet compost weighing 1370 lbs. or 0.62 metric tonnes, (Help Me Compost, 2022), we estimate total application rate of compost of 1.8 metric tonnes of compost. Applied across the current row crop systems, this is 1.8 metric tonnes of compost applied across 0.53-acres for an application rate of about 3.6 metric tonnes/acre.

<u>No-Till</u>

[redacted] staff reported that they try, as a practice, to leave the soil undisturbed; any tilling is minimal and done by hand. This has the benefit of leaving the soil microorganisms undisturbed where they will continue to lock up carbon for deep sequestration and soil building. Tillage practices under the NRCS and UCANR (Mitchell, et al., 2009) typically apply to larger-scale row crop systems and aim to leave some matter of plant residue in the ground during the non-growing season (i.e., mowing corn stalks to a certain height, leaving root matter in the ground to hold soil). [redacted] has expressed a desire to have something in the ground year round, producing food for their CSA boxes. While the practices are different, functionally the results are the same.

Map 5. [redacted] *Current Climate Smart Agriculture Management Practices*

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Table 2. [redacted] *Current Climate-Smart Ag Practices*

Climate-Smart Practice	NRCS Conservation Practice Standard	CO_2e Sequestered Annually (tonnes)	Co-Benefits	Reference
Cover Crop	340	0.65	Improved soil organic matter, soil fertility, increased soil moisture holding capacity, increased drainage, weed suppression	COMET-Planner
Mulching	484	0.15		COMET-Planner
Compost Application	Pending	3.28		COMET-Planner
Hedgerow	422	0.42	Provide habitat for wildlife, improve microclimate, stabilize soils, improve water quality and habitat diversity, reduce water loss	COMET-Planner
No-Till	329	0.20	Reduced labor cost, reduced soil organic carbon loss, improved mycorrhizal health and function	COMET-Planner
	Total	**4.86**		

Climate Smart Practice Recommendations

CCRCD developed the following recommendations after site visits and correspondence with [redacted] staff, and is basing these recommendations on the planned phase map for the [redacted]

Cover Crop

CCRCD recommends that [redacted] continue to use cover crops as needed to achieve management goals of the [redacted] Recognizing that the non-production season is short, [redacted] may consider retiring rows for a season to implement a cover crop over the course of a couple weeks or month to sequester carbon dioxide, increase nitrogen, or support other management goals, and provide rest to the soil between plantings. [redacted] staff reported that some rows within the row crop are prone to ponding as a result of winter rains or overwatering. In these areas, [redacted] may consider a regiment of cover crops that includes species that improve drainage (daikon radish, etc.)

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In the orchard, CCRCD recommends a concerted weed removal effort to cut down on invasive weeds and allow the orchard to fully absorb nutrients, water, and other needed plant growth elements to grow and produce more fruit. As part of this process, CCRCD recommends developing an integrated pest management plan for the orchard to first identify and assess the weeds on site, develop action plans and timelines, and then work to keep the orchard weed free. While string trimming weeds is one possible option, CCRCD recommends exploring a potential "chicken lawn mower," a smaller chicken coop that can be moved through the orchard to allow the chickens to eat the weeds while they're small and fertilize the soil underneath. Continued mulching (discussed later) may help suppress weed growth as well.

When the weeds have been cleared, CCRCD recommends continuing to implement a perennial cover crop in the orchard. RCD Staff observed red clover that had successfully grown in the orchard, providing pollinator forage for bees and butterflies. [redacted] should consider the management practice goals of the orchard when selecting a seed mix, and CCRCD can assist in that effort when the time comes.

Compost Application

Based on design plans, [redacted] plans to continue to make compost on site, albeit at a much smaller scale. Currently, CCRCD and [redacted] staff estimate an application of approximately 3.6 metric tonnes/acre per year. The California Department of Food and Agriculture's Environmental Farming Act Science Advisory Panel recommends that for a cropland system like the [redacted] compost should be applied anywhere from 3-5 tons/acre for higher nitrogen composts (C:N≤11) and 6-8 tons/acre/year for lower nitrogen composts (C:N>11). In orchard systems, these recommendations drop to 2-5 tons/acre/year for high nitrogen compost and 6-8 tons/acre/year for low nitrogen compost (Gravuer & CDFA, 2016). With lower on-farm generated compost, [redacted] may need to truck more compost from outside sources in order to meet farm goals.

However, as time goes on and with improved soil building techniques, compost application may not be as crucial once a target soil organic matter is achieved. Still, soil building is a slow process, so it is highly recommended that both the orchard and the row crops receive healthy applications of compost.

While the current on-farm produced compost is made of plant material, pulp, and straw (a high carbon, low nitrogen compost), CCRCD recommends continuing to monitor the field and assessing soil conditions to determine if a higher nitrogen compost is needed to achieve soil health goals.

In general, higher carbon compost (C:N>11) provides more available carbon for microorganisms to lock up into deeper sequestration, promoting better soil health. Higher nitrogen composts can more easily lose nitrogen to the atmosphere in the form of methane or nitrous oxides and are characterized by bad odors, and have the potential to spontaneously combust if created at the wrong ratio. With regards to cropland use, the needs of different fields will require different compost types as time goes on. Soil monitoring should inform needs in order to better manage on-farm created compost.

CCRCD Staff recommend establishing monitoring logs for compost creation and getting compost tested from time to time to determine if the compost created on site is meeting the goals of [redacted] Monitoring logs should include raw materials, notes on the method of composting, and temperatures during the process. An example monitoring log is included in Appendix J. Further, monitoring logs should be cross-referenced with compost testing. Many businesses that

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test soil will also test compost for similar chemical breakdowns. The California Department of Food and Agriculture maintains a list of CDFA Recommended Soil Analytical Labs that test soil under the CDFA Healthy Soils Incentives Program.

Regarding the [redacted] staff concern of compost leeching to groundwater and/or San Pablo Creek, a review of relevant literature suggests that this in an ongoing research endeavor across the county and should continue to be monitored, but is likely not of immediate concern for [redacted] given the size of the composting operation. A report by David M. Crohn out of UC Riverside, found that “Compost has the ability to absorb and store a considerable amount of water and concentrated nutrients. Therefore, the runoff volume of water during a rain event from soil treated with compost is significantly reduced. Although the concentration of nutrients in the runoff can be highly concentrated, due to the significantly lower volume of runoff, the overall mass of nutrients is comparatively low (Crohn, 2011). In general, with compost applications and improved soil health, soil and nutrient water holding capacity increases (see next section for more discussion). With less water flowing off the farm into the creek or groundwater, nutrient movement is also reduced.

Further studies by Dr. Stephanie Hurley et. al, out of the University of Vermont found that nutrient leaching from compost is tied closely with saturation of soils, namely saturation of chemicals and nutrients (Hurley, Shrestha, & Cording, 2017). Their research found that compost, used primarily as a green stormwater infrastructure, led to higher nutrient runoff and leaching, mostly because plants weren’t able to uptake nutrients fast enough to prevent them from running off. [redacted] practice of incorporating compost into the ground then immediately planting into it should reduce the issues that Dr. Hurley et al. were researching. All told, incorporation of compost into soils at [redacted] is likely having minimal effect on groundwater and surface water systems nearby given that plants are making use of any nutrients almost immediately after incorporation.

[redacted] staff also inquired about the use of blood meal or fish emulsion fertilizer in place of compost. Blood meal, and fish emulsion fertilizer, are nitrogen-rich fertilizers commercially available for use in homes, gardens, and agricultural settings. Blood meal especially is almost entirely nitrogen, while fish emulsion fertilizer is a more balanced blend of nitrogen, phosphorus and potassium. Both of these products are going to be far higher nitrogen inputs into a farming system, while composting is assumed to be a much higher carbon, low nitrogen input. Testing may show the actual C:N ratio, but blood meal and fish emulsion fertilizer both lack carbon, and as a result, have higher potential to runoff or leach into surface and groundwaters if used incorrectly. Further testing is warranted to determine if, and how much, either of these products would add to [redacted] operation, but absent the soil building carbon in compost, its highly likely that these products could results in higher movement of nitrates and other pollutants into waterways.

Mulching

CCRCD recommends [redacted] continue to mulch the row crops and orchard systems as a means to retain water in the soil and long-term provide carbon and improve soil health. In the orchard especially, CCRCD recommends vigorous mulching as a potential strategy to reduce invasive weed pressures. A 3-4-inch thick layer of wood chips can be an effective barrier to keep weeds manageable, prevent growth, and trap water for use by the orchard.

Hedgerows

CCRCD recommends [redacted] continue to manage planted hedgerows and install more hedgerows on the boundaries of the farm and where possible along paths, driveways, and field edges. CCRCD has identified a number of potential hedgerow opportunities and has included them within this plan based on the Planned Phase Map.

Photo 7. Existing hedgerow along Fred Jackson Way and orchard at the [redacted] *photo by Ben Weise.*

Conservation Cover

Conservation Cover is a management practice recommended by the USDA NRCS that establishes and maintains perennial cover for the purpose of reducing erosion, reducing emissions, increasing habitat, and improving soil health. Typically, this involves taking land entirely out of production, making it a tougher sell for some farms and ranches. [redacted] plans to do just this with the installation of the Ohlone Reflection Garden at the south west corner of the [redacted] Continued maintenance of these areas is imperative to prevent invasive weeds and non-desired herbaceous plants from dominating, but with selected native plants the reflection garden should self-manage to some degree.

Riparian Herbaceous Cover

The [redacted] is situated on the south side of San Pablo Creek and has the benefit of a buffer from the creek that is managed by the Contra Costa Flood Control and Water Conservation District. Still, [redacted] plans to install a small, riparian herbaceous buffer on the northern fence line that should allow soil and other chemicals to slowly settle out before entering San Pablo Creek. Continued maintenance and promotion of the planted native species will enhance soil health and provide further farm benefits.

Residue and Tillage Management

CCRCD recommends [redacted] continues to practice residue and tillage management to reach soil health goals, reducing disturbances to the soil as much as possible while still putting seeds or plantings in the ground. This practice is more common in large-scale agricultural operations that leave fields to fallow over winter or a period. Since [redacted] seeks to have something in the ground year round for food production, the goals of this practice are achieved, as the soil is held year round by roots and other plant structures. Should [redacted] decide to rest a row for a season or longer, CCRCD recommends working with CCRCD Staff, NRCS Staff, or UCCE Staff to develop residue management plans, ensuring that soil health gains are not lost during the rest period.

Map 6. Recommended climate-smart agriculture management practices for [redacted]

Table 3. [redacted] *Recommended Climate-Smart Ag Practices*

Climate-Smart Agricultural Practice and	NRCS Conservation Practice Standard	CO2e Sequestered (tonnes CO2 equivalent/year)		Co-Benefits	Reference
		Annually	**Over 20-Years**		
Cover Crop	340	0.93	18.6	Improved soil organic matter, soil fertility, increased soil moisture holding capacity, increased drainage	COMET-Planner
Compost Application	Pending	4.71	94.2		HSP COMET-Planner
Mulching	484	0.21	4.2		COMET-Planner
Hedgerow Planting	422	2.81	56.2	Sequester carbon, improve microclimate stabilize soils, improve water quality, and habitat diversity, reduce water loss.	COMET-Planner
No Till	329	0.29	5.8	Reduced labor cost, reduced soil organic carbon loss, improved mycorrhizal health and function	COMET-Planner
Conservation Cover	327	0.20	4	Reduced erosion, increase soil organic matter, increased pollinator habitat	COMET-Planner
Riparian Herbaceous Buffer	390	0.03	0.6	Reduced erosion, reduced discharge into waterways, increased soil organic matter, increased wildlife habitat	COMET-Planner
	Total	**9.18**	**183.6**		

Soil, Water, and Carbon

NRCS suggests that a 1% increase in soil organic matter results in an increase in soil water holding capacity (WHC) of approximately 1 acre inch, or 27,152 gallons of increased soil water storage capacity per acre. A 1% increase in soil organic matter represents roughly 20,000 pounds (10 short tons) of organic matter, or 5 short tons of organic carbon. Table 4 shows estimated additional water storage capacity associated with soil carbon increases on the [redacted] resulting from full implementation of the [redacted] Carbon Farm Plan over 20 years.

Total estimated additional water storage capacity associated with soil carbon increases on the [redacted] resulting from implementation of the carbon farm plan is estimated to be 0.78-acre-feet, or approximately 254,146 gallons of water. This analysis is assumed conservative, yet reveals the potential significance of even small increases in soil carbon storage for overall farm dynamics.

Table 4. Estimated Additional Annual Soil Water Holding Capacity (WHC) at [redacted] *With Carbon Farm Plan Implementation*

CONSERVATION PRACTICE(S)	20 YEAR CO2e (Mg)	20 YEAR SOIL ORGANIC MATTER INCREASE (Mg)	ANNUAL WHC INCREASE BY YEAR 20 (AF)
Cover Crops (CPS 340)	18.60	10.14	0.09
Mulching (CPS 484)	4.20	2.29	0.02
Compost Application on Cropland	94.2	51.31	0.47
Riparian Herbaceous Cover (CPS 390)	0.60	0.33	0.00
Hedgerow Planting (CPS 422)	56.20	15.31	0.14
Conservation Cover (CPS 327)	4.00	2.18	0.02
Reduced Tillage to No Till	5.8	3.16	0.03
TOTAL	**183.60**	**84.74**	**0.78**

*** allocates ½ of sequestered Carbon to soil pool

Discussion

Average annual CO_2e reduction values for the [redacted] are summarized by Table 5. Actual sequestration of CO_2 in response to management interventions and conservation practices are not expected to be linear over time, and are expected to vary annually. Length of time during which practices will sequester carbon also varies among individual practices. Terrestrial carbon sequestration resulting from each practice tends to increase cumulatively to maturity and then tends to decline, though remaining net positive relative to baseline conditions for many years. This underscores the value of periodic renovation of windbreaks and shelterbelts, periodic reapplication of compost, and long-term maintenance of all carbon beneficial practices to maintain high levels of carbon accumulation in the farm system.

Table 5. Summary Table of Carbon Capture Potential on [redacted]

CONSERVATION PRACTICE(S)	Annual CO_2e Sequestration	20-year CO_2e Sequestration	80-year CO_2e Sequestration
Cover Crops (CPS 340)	0.93	18.60	74.4
Mulching (CPS 484)	0.21	4.20	16.8
Compost Application on Cropland	4.71	94.2	376.8
Riparian Herbaceous Cover (CPS 390)	0.03	0.60	2.4
Hedgerow Planting (CPS 422)	2.81	56.20	224.8
Conservation Cover (CPS 327)	0.2	4.00	16
Reduced Tillage to No Till	0.29	5.8	23.2
TOTAL	**9.18**	**183.6**	**734.4**

Values presented in the Table 5 are best understood as gross CO_2e sequestered through the implementation of the various on-farm practices at the spatial and temporal scales on the Carbon Farm Plan as a whole. Greenhouse gas emissions associated with these practices are generally accounted for in the models used (COMET-Farm, COMET-Planner, etc.). Exact emissions—and sequestration—achieved from practice implementation at the [redacted] cannot be determined precisely; however, sequestration values presented here are based on conservative estimates and are likely to be exceeded in real world application.

In some cases, rates of accumulation of CO_2e may fall below emission rates, resulting in temporary net increases of greenhouse gases. For example, initial greenhouse gas costs of compost production or riparian restoration may exceed first year sequestration rates.

Conclusion

There is significant potential for additional greenhouse gas reduction and terrestrial carbon capture at the [redacted] Through implementation of the conservation practices described above, an estimated 183.65 tonnes CO_2e could be sequestered in soils, as well as above and below ground biomass over 20 years. There is also potential for additional on-farm carbon capture over this period through the reapplication of compost, through the renovation of hedgerows at maturity and through the implementation of other carbon-beneficial practices not currently included in this carbon farm plan.

At 4.71 tonnes CO_2 per year, the application of compost to the orchard and row crop systems is the single largest opportunity for greenhouse gas reductions. On a per acre basis, hedgerow planting offers the greatest opportunities for carbon capture and storage in above and below ground biomass over a 20 to 80 year time frame.

Overall, the estimated 183.6 Mg CO_2e which could potentially be sequestered over 20 years is equivalent to greenhouse gas emissions from 40 passenger vehicles driven for one year or 445,308 miles driven by an average passenger vehicle, or the energy use of 36 homes for one year. (USEPA, 2022)

Monitoring

Practice monitoring (plant survival, compost applications, soil cover etc.) should be carried out in coordination with annual inspections by [redacted] staff and/or project managers from the Contra Costa RCD or other organizations involved in project implementation. Soil C and other ecosystem services should be monitored in accordance with market or voluntary protocol requirements (if applicable). Baseline data and records of implementation activities, including locations, extent of project(s), dates of implementation, etc. should all be included in plan implementation documentation.

This plan should be viewed as a living document. It should evolve as practices are implemented and new information and new tools become available. Additional carbon-beneficial practices may be considered for inclusion in the plan in the future. Greenhouse gas values presented here as associated with specific practices are considered to be both conservative and based upon the best available information at the time of this plan's preparation (June 2022).

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Short Term Action Plan and Phases

Because the scope of the Carbon Farm Plan is extensive, practices are likely to be implemented over time, based upon greenhouse gas and co-benefits, available funds, and farm priorities. In the below table, CCRCD Staff have aligned practice implementation based on the Phased Construction Plan for the [redacted]

In general, cover cropping, mulching, compost application, and reduced tillage should be considered annually on both the row crop and orchard systems. Mulching should also be considered in non-production agriculture spaces as a way to retain water and suppress weeds.

In Phase 2, the northern end of the [redacted] is slated to be developed for a variety of built structures. Following construction of these buildings, the riparian herbaceous cover will be planted. Additionally, hedgerow opportunities may exist alongside some of these buildings or in nearby areas.

In Phase 3, the building of the Main Barn and History Walk could result in opportunities for hedgerow planting and installation.

In Phase 4, further building of the commercial kitchen, offices, and amphitheater could result in opportunities for hedgerow planting and installation.

In Phase 5, with the construction of the Ohlone Reflection Garden, [redacted] would be implementing the Conservation Cover management practice.

Table 6. Phase Map and Management Practice Implementation Considerations

Phase	[redacted] **Construction**	**Management Practice Consideration**
Phase 1	Utility On-Site Connections Utility Underground Work Site Grading Temporary Site Improvements	Cover Crops Mulching Compost Application
Phase 2	Greenhouse Shade House Composting Toilet Watershed Classroom Toolshed + Breakroom Soil & Compost Shed Back Drive/Entry Lay Down Yard Row Crops Orchard Outdoor Classrooms Upper Portion of History Walk	Cover Crops Mulching Compost Application Riparian Herbaceous Cover Hedgerow Planting Reduced Tillage/No-Till

Phase 3	Main Barn: Farm Stand Main Barn: Wash & Pack Main Barn: Multipurpose Room Front Drive/Entry Middle Portion of History Walk West Portion of the Heart of the Farm	Cover Crops Mulching Compost Application Hedgerow Planting
Phase 4	Commercial Kitchen + Café Herb Shed [redacted] Offices Amphitheater Children's Garden East Portion of the Heart of the Farm	Cover Crops Mulching Compost Application Hedgerow Planting
Phase 5	Main Pedestrian Entry Lower Portion of History Walk Ohlone Reflection Garden Native Plantings	Cover Crops Mulching Compost Application Hedgerow Planting Conservation Cover

The above table references approximately when the various management practices recommended in this plan could be incorporated into [redacted] planned phase build-out of the [redacted] Generally, compost application, cover cropping, mulching, and reduced or no-tilling is something to be considered annually. For more of the single instance practices like hedgerow planting, conservation cover, and riparian herbaceous cover, those are included within the approximate phase that the surrounding area will be developed.

Funding and Financial Assistance

All of the management practices recommended are, at a minimum, partially funded through financial assistance programs run through various levels of local, state, and federal governments. In Table 7, CCRCD staff have compiled known programs that could lead to partial or full implementation funding. This list is not exhaustive, and additional funding sources may come to light. CCRCD staff recommend connecting with them to determine the latest status of any of these funding programs or new programs to come.

Table 7. Currently Known or Available Funding for Climate-Smart Agriculture

Funding or Implementation Source	Description
CDFA Healthy Soils Incentives Program (HSP)	Under the CDFA Healthy Soils Incentives Program, farmers can apply through CCRCD for partial cost-share funding to implement climate-smart agriculture practices for three years. In 2021, this program received $67.5 million from the California Budget and received $90 million+ in applications and will likely be funded again.
CDFA Healthy Soils Demonstration Program	Under the CDFA Healthy Soils Demonstration Program, RCDs or other research groups can apply for funding to demonstrate climate-smart agriculture with partner farms and/or research new practices. In 2021, this program received 12 applications for $2 million and funded 7 projects for $1.1 million. This program will likely be funded again, but CCRCD Staff recommend pursuing the Incentives Program.
USDA NRCS Environmental Quality Incentives Program (EQIP)	Under the 2018 Farm Bill, the USDA NRCS is authorized to provide cost-share contracts to farms to conserve natural resources and address ongoing resource concerns. This program will very likely continue on in perpetuity through the federal government.
Xerces Society Hedgerow Kits	The Xerces Society is a non-profit organization with the goal of conserving invertebrates and their habitats. Through the California Monarch and Pollinator Habitat Kits, farms can apply for free hedgerow kits (cover approximately 450 linear ft) to implement on their farm. CCRCD Staff can assist in applications, and potentially in installation depending on available funding.
Project Apis M. Seeds for Bees	Project Apis m. is a non-profit that funds and directs honey bee research to enhance health and vitality while improving crop production. Through the Seeds for Bees program, Project Apis m. provides free cover crop seed to interested farmers to promote pollinator forage. CCRCD staff can assist in applications to this program.
Contra Costa Fish and Wildlife Committee	The Contra Costa Fish and Wildlife Committee provides annual grants from polluter fees and/or hunting tag sales to increase the conservation of wildlife within Contra Costa county. Priorities and funding levels change year to year, but typically the committee is interested in projects that will directly improve habitat quality or restore habitat. While it is

	unclear if they are interested in farm habitat, this could be a potential source of funding for plants that provide pollinator and wildlife habitat.
Zero Foodprint/Restore CA	Zero Foodprint is a non-profit organization mobilizing the food world around agricultural climate solutions and runs the Restore CA program, a program that provides cost-share funding to farms interested in implementing carbon farm plans and climate-smart agricultural practices. In Summer 2022, Zero Foodprint intends to grant $200,000 to farms throughout California.

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Appendix

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C. 2021 Soil Control Lab Testing
D. [redacted] Phasing Site Map
E. COMET-Planner Report Existing Practices
F. COMET-Planner Report Recommended Practices
G. [redacted] Existing Practice Map
H. [redacted] Recommended Practice Map
I. Recommended NRCS Conservation Practice Standards
J. Compost Monitoring Log
K. Water Testing Best Management Practices

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United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Contra Costa County, California

[redacted] Soil Survey

April 4, 2022

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

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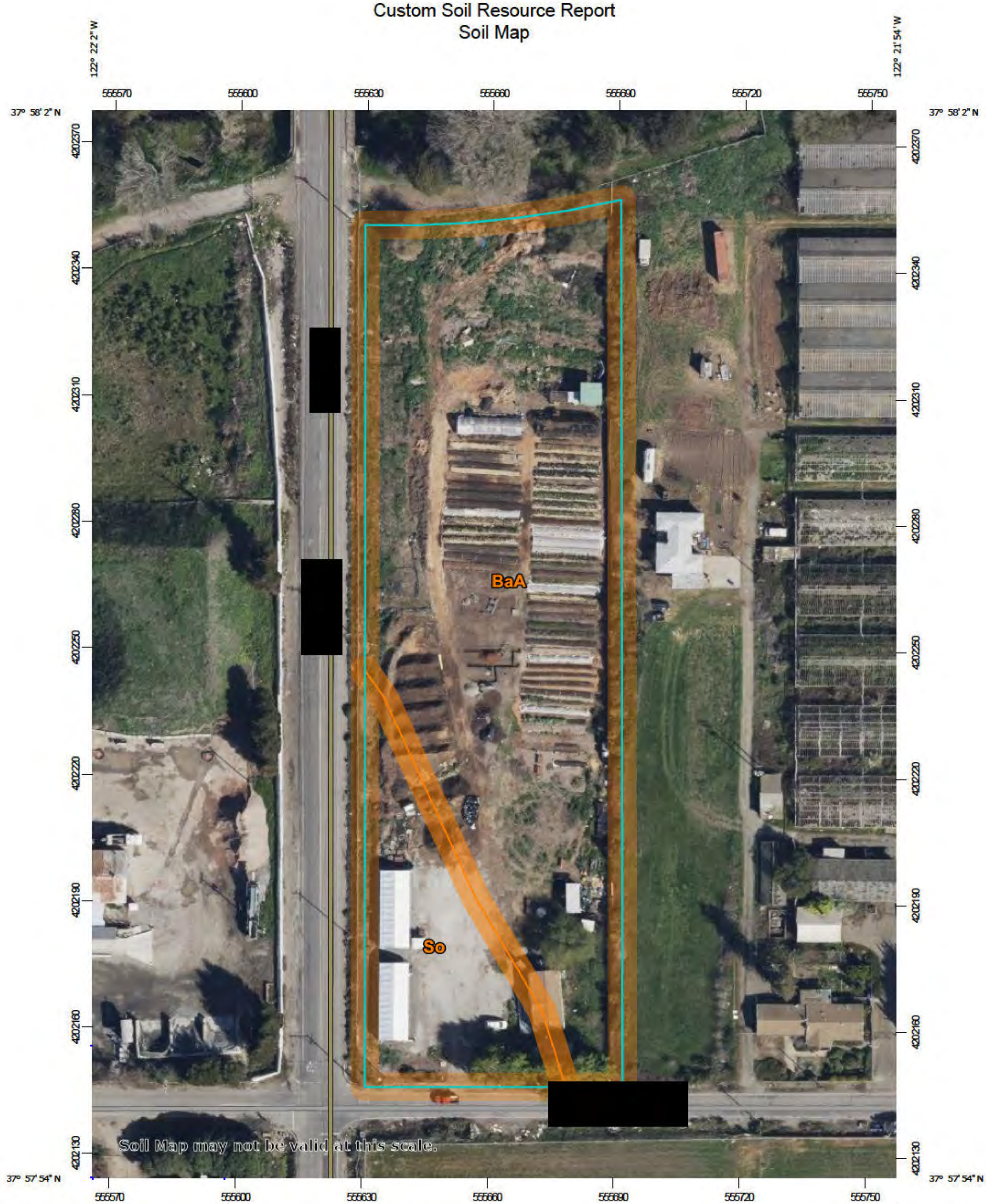
Soil Map



Map Scale: 1:1,230 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0, 15, 30, 60, 90

Feet: 0, 50, 100, 200, 300

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Contra Costa County, California
Survey Area Data: Version 18, Sep 9, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 7, 2021—Mar 27, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BaA	Botella clay loam, 0 to 2 percent slopes, MLRA 14	2.5	80.3%
So	Sycamore silty clay loam, 0 to 2 percent slopes, MLRA 17	0.6	19.7%
Totals for Area of Interest		**3.1**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Contra Costa County, California

BaA—Botella clay loam, 0 to 2 percent slopes, MLRA 14

Map Unit Setting

National map unit symbol: 2tyz5
Elevation: 0 to 1,110 feet
Mean annual precipitation: 16 to 29 inches
Mean annual air temperature: 55 to 60 degrees F
Frost-free period: 300 to 360 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Botella and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Botella

Setting

Landform: Flood plains, alluvial fans
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread, talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from sedimentary rock

Typical profile

Ap - 0 to 9 inches: clay loam
Bt - 9 to 14 inches: clay loam
2Bt - 14 to 41 inches: silty clay loam
3Bt - 41 to 65 inches: sandy clay loam
3C - 65 to 72 inches: sandy clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 9.8 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: C
Ecological site: R014XG907CA - Loamy Bottom
Hydric soil rating: No

Minor Components

Pachic argixerolls, very slowly permeable clay sub soil

Percent of map unit: 5 percent
Landform: Swales, depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Dip
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: Yes

Clear lake, hydric

Percent of map unit: 3 percent
Landform: Depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Dip
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: Yes

Conejo

Percent of map unit: 3 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Garretson

Percent of map unit: 3 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Elder

Percent of map unit: 1 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

So—Sycamore silty clay loam, 0 to 2 percent slopes, MLRA 17

Map Unit Setting

National map unit symbol: 2xcbp
Elevation: 10 to 80 feet
Mean annual precipitation: 14 to 24 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 328 to 360 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Sycamore and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sycamore

Setting

Landform: Alluvial fans
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from sedimentary rock

Typical profile

Ap - 0 to 4 inches: silty clay loam
A - 4 to 15 inches: silty clay loam
Bw1 - 15 to 23 inches: silt loam
Bw2 - 23 to 27 inches: silt loam
C - 27 to 31 inches: loamy fine sand
B'w3 - 31 to 42 inches: silty clay loam
B'w4 - 42 to 56 inches: silty clay loam
B'w5 - 56 to 66 inches: silty clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.60 in/hr)
Depth to water table: About 40 to 60 inches
Frequency of flooding: RareNone
Frequency of ponding: None
Calcium carbonate, maximum content: 2 percent
Maximum salinity: Nonsaline to very slightly saline (0.3 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 4.0
Available water supply, 0 to 60 inches: High (about 11.3 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Sorrento

Percent of map unit: 5 percent
Hydric soil rating: No

Laugenour

Percent of map unit: 4 percent
Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Omni

Percent of map unit: 3 percent
Landform: Depressions
Hydric soil rating: Yes

Delhi

Percent of map unit: 2 percent
Hydric soil rating: No

Unnamed

Percent of map unit: 1 percent
Landform: Depressions
Hydric soil rating: Yes

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Summary: Soil Testing at [redacted]

By Joshua Arnold and Sarick Matzen, Ph.D. students, Environmental Science, Policy, and Management, UC Berkeley
June 12, 2018

Goals: We facilitated soil testing for contaminants common to urban soils and nutrients*. We then worked with [redacted] to develop a soil management plan to build healthy and safe soils for community agricultural use.

Approach: In conjunction with [redacted] community members we collected composite soil samples to confirm the distribution of possible contaminants in the soil. We had samples analyzed for metals (CFR 503 metals) and organic chemicals, including a preliminary broad-spectrum scan for organic compounds, plus testing for asphalt-related contaminants (polycyclic aromatic hydrocarbons (PAHs)).

Findings:

- *Metals:* Levels of all metals except for lead were typical for California soils. Lead was slightly elevated above background levels in the production space soil, but not above current guidelines for residential and urban agricultural soils (including gardening with children).
- *Organic chemicals:* Asphalt is visibly present in the soil, and small amounts of organic contaminants in asphalt were found in the tested soil. Some of these contaminants were present above EPA guidelines. These contaminants are most likely not absorbed by plants and can be broken down over time in biologically active soils.
- *Nutrients and soil quality:* Overall, nutrient levels are reasonable for Bay Area soils, but levels of some key nutrients (phosphorus, potassium) were low in the production area soil. The production area soil is low in beneficial organic matter and is compacted.

Conclusions and recommendations:

- *Add large quantities of organic matter:* Adding organic matter (manure, compost, cover crops, mulch, etc.) will dilute contaminants and make them less bioavailable and increase the microbial life that breaks down organic contaminants over time. Adding soil organic matter also increases nutrient content and water holding capacity while decreasing compaction, creating higher quality agricultural soils.
- *Remove asphalt to the extent possible:* Remove asphalt fragments found in production space soil and grow food crops in soil with lower amounts of visible asphalt.
- *We consider this soil to be suitable for agricultural production* if these recommendations are followed, and expect to see a reduction of organic contaminants as the soil management plan is implemented. Follow up testing will be completed at a later date.

*Samples were analyzed for contaminants by Brookside Laboratories (New Bremen, OH) using EPA methods, and for nutrients by the University of Massachusetts (Amherst, MA). We work under the guidance of our advisers, Dr. Miguel Altieri and Dr. Céline Pallud at the University of California, Berkeley.

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[redacted]

Soil Testing Report

Joshua Arnold
Sarick Matzen
Environmental Science, Policy, and Management Department
University of California, Berkeley
June 12, 2018

SCOPE OF WORK AND PURPOSE

[redacted] acquired a new plot of land in [redacted] California for use as a farm and community space (referred to here as the [redacted] Given the condition of the land and the unknown effects of a legacy of dumping on the site, it was determined that the soil would have to be significantly improved to ensure quality food production and safety of future farmers and consumers. [redacted] reached out the the Urban Soils Project and UC Berkeley graduate students Sarick Matzen and Joshua Arnold for assistance in determining baseline levels of contaminants and nutrients in the soil of the developing farm. While the soil had been tested for contaminants by the City of [redacted] previously, those samples were discrete samples, and narrowly focused on pesticide and arsenic contamination. Better resolution of contaminant and nutrient levels were needed to develop a soil building plan and determine long-term strategies for safely transitioning the space for agricultural use. We decided to analyze for a broad spectrum of contaminants including metals and polycyclic aromatic hydrocarbons (PAHs). PAHs are released when organic materials (wood, fossil fuels) are partially burned (for more information, please see (http://superfund.oregonstate.edu/superfund/all-about-pahs). Both metals and PAHs could have been distributed in the soil due to the illegal dumping, refinery activities, and the asphalt that is found on the property.

SITE DESCRIPTION AND CONDITIONS

The [redacted] site at [redacted] in [redacted] CA was abandoned for years and had been used as a de facto dump site. Adjacent to a 7 acre greenhouse complex, the site previously was used by the Black Cowboy Association as stables. When [redacted] first accessed and began improving the property, household refuse and used motor oil were discovered, as well as degraded asphalt (dumped and from an old road). The plot was overgrown with various common Bay Area ruderal plants such as Himalayan blackberry (*Rubus armeniacus*), fennel (*Foeniculum vulgare*), and other pernicious weeds. Goats were used initially to clear undergrowth and the blackberry and other remnant shrubs were removed through mechanization.

METHODS

We chose a multi-increment sampling method for soil sampling. With this method, an area or zone of soil (technically known as a decision unit (DU)) is divided up into approximately 50 increments. Samples are taken from each increment and combined to yield a composite sample for the zone. This method captures the variability of contaminant levels in the sample, reduces experimental error, and gives results that are highly reproducible. Laboratory analysis of samples returns an average concentration of contaminants for an area. Since soil contaminant guidelines are based on average concentrations, this multi-increment sampling method returns information useful for assessing the safety of a site. Furthermore, when sampling we collected each composite sample with three duplicate samples (i.e., in triplicate) to give us a good idea of the variability of contaminants levels in the zone. This multi-increment sampling method is recommended by the City of Berkeley, UC Berkeley Environmental Health and Safety, and US EPA Headquarters, and is gaining acceptance by the California Department of Toxic Substances Control. We trained [redacted] interns including Dreon, Jose, Ruben, Javier, and other interns to perform the sampling. They did an excellent job.

We first collected a 5 preliminary discrete samples from the Production space and Pre-existing Pile areas in fall 2015, and had these analyzed for metals and scanned for organics.

We then proceeded with multi-increment sampling over summer-fall 2016. We first divided the farm area up into five zones based on several factors including current state of the soil, past activities, and future use (Figure 1). When our soil sampling began, [redacted] had already identified several areas that contained asphalt and concrete rubble. Portions of these areas had been excavated into piles and were being sieved. Our five zones included a pile of excavated soil, a pile of sifted soil, a pre-existing pile, as well as the ground in the Production space area and orchard area.

Zone	**Sample names**	**Description**
Production space	Blue 1, Orange 2, Green 3	Production space area between excavated pile to west and blackberries/pre-existing pile to east.
Orchard	North Fence Orange, North Fence White, North Fence Green	Orchard area along western fence
Pre-existing pile	9/24/16 East, West, Top	The pile between Production space and blackberry areas, just to north of spiral raised beds.
Asphalt pile	ASP 1, ASP 2, ASP 3	Long pile of soil+asphalt excavated from Production space area, to be sifted
Sifted pile	SIFT 1, SIFT 2, SIFT 3	Pile of sifted soil between Production space and

		blackberry areas, to north of pre-existing pile

Each zone was sampled and analyzed separately. Samples for the Production space and Orchard zones were collected *in situ*. For these areas, we divided each zone into approximately 50 equally sized increments. Within each increment, we dug a hole 1 foot (30 cm) deep. We used clean stainless steel spoons to scrape 1 spoonful of soil off the side of the hole and placed this spoonful in a clean bucket. We repeated this process for each increment, to collect a composite sample containing 1 spoonful of soil from all 50 increments. We repeated this process to end up with a total 3 composite/incremental samples (A, B, C) per zone.

For pile samples, we considered that the piles were reasonably well mixed. We stretched a tape measure around the pile (for round piles) and down the pile (for the long excavated pile) and divided the circumference/length into 50 increments. Like for the *in situ* samples, for each pile we collected and combined soil from each of the 50 increments in 3 replicate samples.

Samples were air dried, returned to the Pallud Lab at UC Berkeley, and disaggregated to pass through a 2mm mesh. Ground samples were then well mixed, subsampled, and shipped to Brookside Laboratories (New Bremen, OH) for contaminant analysis and University of Massachusetts Soil and Plant Testing Laboratory (Amherst, MA) for nutrient analysis.

Samples were analyzed for contaminants including metals (EPA Methods 3050B and 6010C) and polycyclic aromatic hydrocarbons (PAH's; EPA Methods 3550B and 8270). Routine nutrient analysis included analysis for extractable macro and micro plant nutrients, pH, cation exchange capacity, and percent base saturation.

ANALYTICAL RESULTS

Metals:

Metals were at or below California background levels (Bradford et al., 1996), with the exception of 1 sample which had elevated lead. The preliminary and multi-increment samples were low in metals (Table 1). Only one sample (Production space sample Blue 1) was over background levels (97 mg/kg upper limit) for one element (lead (Pb), 106 mg/kg). Considering the three replicates for the production space, the upper limit for lead in these samples is 121 mg/kg (calculated using a 95% confidence interval T-test). This upper limit level of lead found in the Production space is well below the current US EPA Residential Soil Screening Level (SSL) for lead (400 mg/kg). However, experts are considering lowering this SSL, with 200 mg/kg being used in some EPA work [1]. A well-regarded fact sheet on gardening in lead-contaminated soils suggests that soils with less than 150 mg/kg total lead are safe for gardening, including gardening with children [2]. The upper limit for the Production space is below these more conservative thresholds for lead in urban agriculture soils.

This same replicate sample (Production space Blue 1) had a higher than recommended level of extractable lead (29 mg/kg, whereas the UMASS recommendation is < 22 mg/kg). Forms of lead that are highly extractable (soluble) include lead paint dust and lead residue from bullets. This elevated extractable lead was found in only 1 of the 3 replicate samples for the Production space area, suggesting that the lead present in the Production space area is not uniformly available. It is possible this replicate contained a particle of lead paint or some other form of more soluble lead.

Plants do not take up very much lead, so the primary way people will be exposed to any lead that is present in the soil is by direct contact with the soil, or by eating unwashed produce that has soil containing lead stuck to the edible portion.

Remediation of lead contamination:

1) We recommend adding organic matter to the soil to remediate the lead contamination. This will dilute the total lead concentration and reduce the availability of the lead that is present. Overall, because the value for that Production space sample is below the EPA Residential SSL, and because we anticipate that the soil will be well amended with organic matter, we do not believe this is cause for concern.
2) While the overall risk from the lead in this soil is low, we recommend following best management practices for working in lead-containing soils, because there is some lead present. These practices include:
    a) Cover soil between plants and on paths with mulch
    b) Wash all produce before eating

Soil samples indicate natural history of site: The chromium and nickel levels seem to reflect the natural serpentine parent rocks of the California coast. The chromium and nickel co-vary linearly in most samples ($R^2 = 0.8$), suggesting this is a natural geologic relationship, although the nickel in the Production space area is slightly higher than predicted by the relationship in other samples. We checked the chemical form of the chromium to confirm it is present as the naturally- occurring reduced form, chromium(III), and not the more toxic oxidized form, chromium(VI).

Organics:

Low levels of organics related to asphalt were found: We had the preliminary discrete samples scanned for a wide range of organic compounds including common herbicides, fungicides, insecticides, polycyclic aromatic hydrocarbons, and semivolatile organic compounds including hydrocarbons. This type of scan is qualitative and indicates the presence or absence of a particular compound. No organic compounds were found in these discrete samples, including no beneficial organic matter as well as no organic contaminants. The lack of beneficial organic matter is a concern that can be addressed through consistent soil building (i.e., adding organic matter). While is it positive that no harmful organic compounds were identified in the preliminary samples, we know there is asphalt in the soil because it is visible to the naked eye in the soil of the Production space area and the excavated and sifted piles.

To follow up on possible contamination from asphalt, we had the multi-increment samples analyzed for PAHs, some of which are found in asphalt. The PAH test results (Table 2) show that 6 of the 16 compounds tested for could not be detected in the soil. No PAHs were found in the Orchard area sample and the Pre-existing Pile sample. Some PAH compounds are present in one of the replicates of the Production space area, and in the Asphalt Pile and Sifted Pile samples, which is not a surprise since we know there are small asphalt particles in the soil. Of the 10 compounds found in the soil, 2 (benzo (a) anthracene and benzo (a) pyrene) are present above the EPA Residential SSLs, one (benzo (a) fluoranthene) is present just below the SSL, and 4 compounds (anthracene, fluoranthene, phenanthrene, and pyrene) do not have an EPA SSL established. Generally, these compounds individually and as mixtures are considered toxic and carcinogenic. However, they can be broken down by microbial activity or strongly adsorbed to soil where they are not accessible to plants and people. In a study where vegetables were grown in urban garden soil contaminated with 100 times the concentrations found in the [redacted] soils, no PAHs were taken up into the vegetables [3].

Add organic matter to remediate PAH contamination: These compounds can be broken down by microbial activity [3]. We recommend adding substantial quantities of organic matter over the long term to fuel microbial activity and increase air flow by increasing soil structure. While there will be asphalt particles present in the soil for a long time, a healthy microbial community will decompose the PAH compounds as they are released from the decomposing asphalt particles. We consulted with a soil scientists at Kansas State University, Ganga Hettiarachchi, who has worked in urban agricultural systems contaminated with PAHs, and she felt the levels found in these samples did not pose a concern.

Nutrients:

Overall, soil nutrient levels are reasonable for Bay Area soils. Nutrient levels (Table 3) in the orchard area are higher, and in the production space are on par with local vacant lot soils (Santa Fe Right of Way, Berkeley, CA) but lower than a local agricultural soil (UC Berkeley Oxford Tract). The production space also suffers from poor soil quality, including low organic matter and compaction. High extractable lead was found in one of the three replicates from the Production space area, as noted above. High calcium is normal for Bay Area soils. The Pre-existing Pile soil often has higher values for extractable nutrients, suggesting it could be soil brought in from elsewhere. Alternately, the samples could have included goat droppings, since the pile had recently been grazed for weed control.

Follow-up analyses:

Long-term monitoring of PAH’s

Recommendations:

1. *Add and incorporate organic matter*. Due to the low quantity of organic compounds found in test results as well as low-level contamination we recommend continuing with the original soil development plan but emphasize the importance of incorporating organic matter into growing areas at depth through mechanical processes during the initial period of development at the site. Multiple iterations of

adding and incorporating organic matter enable dilution and/or decomposition of harmful compounds.

2. *Continue removal of asphalt* throughout the site at varying scales. Soil with a high density of asphalt particles should be removed entirely while other areas that have been sifted or dispersed should be systematically cleared of larger asphalt aggregates by hand or through mechanization.
3. *Monitor PAHs over the long-term.* The continued degradation of those compounds will be an important indicator of soil health as well as a sign that remediation practices are effective.
4. *In-situ practices to build soil while breaking through native hardpan soils*. Moving forward with different soil treatments in the production area could be beneficial for future soil building strategies.

LIMITATIONS AND EXCEPTIONS OF ASSESSMENT

This assessment cannot wholly eliminate uncertainty regarding the potential for recognized environmental conditions in connection with the site. This report is intended to "reduce, but not eliminate, uncertainty regarding the potential for recognized environmental conditions in connection with a property, and this practice recognizes reasonable limits of time and cost."

This assessment report contains the results of reconnaissance and sampling activities of the Site and surrounding properties conducted throughout September 2016 to January 2017.

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2. Defoe, P. P., Presley, D. & Hettiarachchi, G. M. *Gardening on Lead-Contaminated Soils*. *K-State Research and Extension* **MF3166,** (2014).
3. Attanayake, C. P., Hettiarachchi, G. M., Martin, S. & Pierzynski, G. M. Potential Bioavailability of Lead, Arsenic, and Polycyclic Aromatic Hydrocarbons in Compost-Amended Urban Soils. **944,** 930–944 (2015).

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Tan - Production Space

Green - Orchard

Blue - Sifted pile and two remnant piles from previous dumping, including the Asphalt pile running north/south

Figure 1. Aerial photo of [redacted] with sampling areas highlighted. Photo courtesy of Google Earth.

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Table 1. Metals and metalloids in [redacted] soils.

	Arsenic (As)*		Cadmium (Cd)		Chromium (total) (Cr)		Copper (Cu)		Lead (Pb)	
Location	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD
Production space	8.08	0.36	1.17	0.22	126.80	15.03	59.57	9.67	78.76	25.14
Pre-existing pile	5.45	0.21	0.79	0.04	74.92	12.16	27.84	2.50	20.52	4.00
Orchard	4.49	0.23	0.81	0.01	157.26	67.08	39.85	6.84	35.48	7.65
Sifted pile	4.83	0.47	1.26	0.04	118.81	2.83	34.05	1.56	27.40	0.96
Asphalt pile	5.13	0.40	1.14	0.04	117.36	17.87	30.86	0.55	28.36	3.31
CA background UL**	11		1.7		1579		96.4		97.1	
CA background LL	0.6		0.05		4		9.1		12.4	
CA background avg	3.5		0.36		122		28.7		23.9	
	Mercury (Hg)		**Molybdenum (Mo)**		**Nickel (Ni)**		**Selenium (Se)**		**Zinc (Zn)**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**
Production space	<MDL	<MDL	<MDL	<MDL	105.88	2.47	<MDL	<MDL	160.98	17.16
Orchard	<MDL	<MDL	4.28	NA	99.13	30.22	<MDL	<MDL	115.37	18.02
Pre-existing pile	<MDL	<MDL	<MDL	<MDL	66.14	4.75	<MDL	<MDL	99.73	8.96
Sifted pile	<MDL	<MDL	<MDL	<MDL	82.93	1.52	<MDL	<MDL	85.21	0.76
Asphalt pile	0.49	NA	<MDL	<MDL	83.43	6.76	<MDL	<MDL	82.42	2.15
CA background UL	0.9		9.6		509		0.43		236	
CA background LL	0.1		0.1		9		0.015		88	
CA background avg	0.26		1.3		57		0.058		149	

*All values are mg/kg

**California upper limit (UL), lower limit (LL), and average (Avg) background levels from Bradford et. al, 1996

Table 2. Polycyclic aromatic hydrocarbons (PAHs) in [redacted] soils.

Location	Acenaphthene*	Acenaphthylene	Anthracene	Benzo (a) anthracene	Benzo (a) pyrene	Benzo (b) fluoranthene	Benzo (ghi) perylene	Benzo (k) fluoranthene
Orchard 1**	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Orchard 2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Orchard 3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Production space 1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Production space 2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Production space 3	< 0.1	< 0.1	**0.1975*** **	**0.3475**	**0.2075**	0.3925	< 0.1	0.135
Pre-existing pile 1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Pre-existing pile 2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Pre-existing pile 3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Sifted pile 1	< 0 02	< 0.02	< 0.02	< 0 02	< 0.02	< 0.02	< 0.02	< 0.02
Sifted pile 2	< 0 02	< 0.02	< 0.02	< 0 02	< 0.02	< 0.02	< 0.02	< 0.02
Sifted pile 3	< 0 02	< 0.02	< 0.02	< 0 02	< 0.02	< 0.02	< 0.02	< 0.02
Asphalt pile 1	< 0 02	< 0.02	< 0.02	< 0 02	**0.048**	< 0.02	< 0.02	< 0.02
Asphalt pile 1	< 0 02	< 0.02	< 0.02	< 0 02	< 0.02	< 0.02	< 0.02	< 0.02
Asphalt pile 3	< 0 02	< 0.02	< 0.02	< 0 02	< 0.02	< 0.02	< 0.02	< 0.02
US EPA RSSL, Carcinogenic	NA	NA	NA	0.16	0 016	0.42	NA	1.6

	Chrysene	Dibenzo (a,h) anthracene	Fluoranthene	Fluorene	Indeno (1,2,3-cd) pyrene	Naphthalene (GCMS)	Phenanthrene	Pyrene
Orchard 1**	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Orchard 2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Orchard 3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Production space 1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Production space 2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Production space 3	0.2975	< 0.1	**0.6425**	< 0.1	< 0.1	< 0.1	**0.1975**	**0.515**
Pre-existing pile 1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Pre-existing pile 2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Pre-existing pile 3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Sifted pile 1	< 0 02	< 0.02	< 0.02	< 0 02	< 0.02	0.117	**0.028**	< 0.02
Sifted pile 2	< 0 02	< 0.02	< 0.02	< 0 02	< 0.02	0.089	**0.024**	< 0.02
Sifted pile 3	< 0 02	< 0.02	< 0.02	< 0 02	< 0.02	0.109	**0.023**	< 0.02
Asphalt pile 1	< 0 02	< 0.02	< 0.02	< 0 02	< 0.02	< 0.02	< 0.02	< 0.02
Asphalt pile 1	< 0 02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Asphalt pile 3	< 0 02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
US EPA RSSL, Carcinogenic	16	NA	NA	NA	NA	3 8	NA	NA

*All values in mg/kg.

**Values were not averaged over the three replicates because so many samples had values below the detection limit.

***Values above the US EPA Residential Soil Screening Level (SSL), or values elevated where no SSL exists, are in bold.

Table 3. Nutrient levels and other routine soil test results.

			Extractable macro and micro nutrients and lead (mg/kg)											
Location	**pH**		**Phosphorus (P)**		**Potassium (K)**		**Calcium (Ca)**		**Magnesium (Mg)**		**Zinc (Zn)**		**Boron (B)**	
	Avg pH	**SD pH**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**
Production area	7.70	NA	7.11	0.91	174.29	7.62	4482.62	380.49	758.67	74.43	6.17	0.60	0.70	0.06
Pre-existing pile	6.53	NA	44.99	13.78	630.74	172.70	3727.81	154.46	647.80	101.41	5.46	1.83	1.35	0.20
Orchard	7.41	NA	26.00	1.87	399.21	37.83	4401.66	419.25	477.38	37.38	5.27	1.23	0.98	0.05
Local ag soil*	5.80	NA	26.90	8.11	225.00	40.30	2973.00	491.00	573.00	115.00	12.00	2.83	0.03	0.00
Local vacant lot**	6.98		9.14		111.82		1720.45		470.02		4.42		0.42	
	Iron (Fe)		**Lead (Pb)**		**Aluminum (Al)**		**Sodium (Na)**		**Sulphur (S)**		**Manganese (Mn)**		**Copper (Cu)**	
	Avg	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**
Production area	3.21	0.29	13.37	13.64	11.87	1.25	64.63	12.83	39.11	2.98	31.91	6.70	2.35	0.57
Pre-existing pile	9.13	1.91	1.16	0.27	11.14	1.55	85.30	49.98	79.25	33.01	53.72	8.97	1.24	0.11
Orchard	2.21	0.24	2.41	0.95	4.95	0.51	42.63	3.00	39.09	4.67	16.75	6.30	1.11	0.57
Local ag soil	5.40	0.50	7.10	1.40	19.00	5.70	NA	NA	30.80	5.00	25.40	7.89	0.40	0.09
Local vacant lot	1.39		2.15		2.58		51.98		15.67		7.37		0.43	
				Percent Base Saturation										
	Exch. Acidity	**CEC**		**Calcium**		**Magnesium**		**Potassium**		**Scoop Density**				
	Exch Acid	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**			
Production area	0.00	29.08	2.46	77.08	0.66	21.38	0.65	1.54	0.19	1.24	0.02			
Pre-existing pile	4.30	27.00	2.68	69.59	8.54	19.60	1.20	6.05	1.96	1.03	0.09			
Orchard	0.00	26.94	1.72	81.58	2.53	14.61	1.98	3.81	0.56	1.16	0.05			
Local ag soil	7.50	27.60	4.34	54.00	0.47	17.00	0.82	2.00	0.00	1.13	0.09			
Local vacant lot		13.51		63.88		28.99		2.05		1.32				

* Local agricultural soil is from the University of California, Berkeley Oxford Research Tract

** Local vacant lot soil is from the Santa Fe Right of Way, Berkeley, CA

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and
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Work Order #: 1020003
Account #: 11294
Date Received: Feb 1, 2021
Date Reported: Feb 9, 2021

Soil Report

Debora Supinski
1435 Stanton St
Alameda, CA 94501

Lab Number: 1020003-1/4
Project #/Name: None / None
Sample ID: Row Crops 1st Set

	Your Values (lbs/acre 6" deep)	Suggested Values	
Ammonia (NH_3-N)	33	10-50	OK
Nitrate (NO_3-N)	10	20-100	Low
Total Available N	44	75-150	Low
Phosphorous(P_2O_5)	800	100-300	High
Potassium (K_2O)	5100	779-1298	High
Calcium (Ca)	6200	6636-8295	Low
Magnesium (Mg)	1400	663-1327	High
Sulfate (SO_4-S)	310	100-200	High
Sodium (Na)	290	< 250	See SAR
Chloride (Cl)	380	1-100	High
ECe (dS/m)	1.8	0.2-4	OK
Copper (Cu)	1.4	1 +	OK
Zinc (Zn)	12	3 +	OK
Iron (Fe)	66	8 +	OK
Manganese (Mn)	8.1	4 +	OK
Boron (B)	1.6	1-4	OK
SAR	1.6	0-6	OK
CEC (meq/100gms)	28	10-20	OK
ESP (%)	2.3	0-10	OK
pHs Value	7.2	6.5-7.5	OK
Organic Matter (%)	32		

RECOMMENDATIONS
ALL VALUES lbs/acre 6" deep

100	Nitrogen (N)
0	Phosphorous (P_2O_5)
0	Potassium (K_2O)
6000	Gypsum ($CaSO_4$)
0	Lime ($CaCO_3$)
0	Dolomite ($CaCO_3$ & $MgCO_3$)
0	Sulfur

*Gypsum adds Ca and doesn't affect pH; Lime adds Ca and raises pH; Dolomite adds Ca & Mg & raises pH.

Lime Requirement:
Tons of 100% $CaCO_3$ Lime per Acre 6" deep needed to raise pH of soil to:

pH 6.0 needs	0.0
pH 6.5 needs	0.0
pH 7.0 needs	0.0

Gypsum Requirement (needed for clay treatment)
4.6 tons per acre 6" deep
Gypsum helps the soil structure by "loosening" the soil

Data:			Method
NO_3-N	5.1	mg/Kg	KCl
NH_3-N	17	mg/Kg	KCl
P	180	mg/Kg	Olsen
SP	120	%	Sat
pHs	7.2	unit	Sat
ECe	1.8	dS/m	Sat
Ca	4.8	meq/L	Sat
Mg	3.6	meq/L	Sat
Na	3.4	meq/L	Sat
K	11	meq/L	Sat
Cl	4.3	meq/L	Sat
SO_4-S	3.9	meq/L	Sat
SAR	1.6	ratio	Calc
B	0.79	mg/Kg	CaCl2
Cu	0.68	mg/Kg	DTPA
Zn	5.9	mg/Kg	DTPA
Fe	33	mg/Kg	DTPA
Mn	4.0	mg/Kg	DTPA

Data:			Method
OrgMat	32	%	WalkBk
Org-C	19	%	WalkBk
SMP Bufffer pH	7.07	unit	SMP
GypReq	5.4	meq/100g	GypSol
Ca	3100	mg/Kg	NH_4OAc
Mg	710	mg/Kg	NH_4OAc
Na	140	mg/Kg	NH_4OAc
K	2100	mg/Kg	NH_4OAc

Cation Exchange Capacity (CEC) and Base Saturation Percentages

CEC	28	meq/100gm	Calc.
NH_3-N	0.4	% of CEC	Calc.
Ca	56.1	% of CEC	Calc.
Mg	21.4	% of CEC	Calc.
Na	2.3	% of CEC	Calc.
K	19.8	% of CEC	Calc.
H	0.0	% of CEC	Calc.

Lab Analyst: Mike Galloway

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Work Order #: 1020003
Account #: 11294
Date Received: Feb 1, 2021
Date Reported: Feb 9, 2021

Soil Report

Debora Supinski
1435 Stanton St
Alameda, CA 94501

Lab Number: 1020003-2/4
Project #/Name: None / None
Sample ID: Row Crops 2nd Set

	Your Values (lbs/acre 6" deep)	Suggested Values	
Ammonia (NH_3-N)	32	10-50	OK
Nitrate (NO_3-N)	< 4	20-100	Low
Total Available N	35	75-150	Low
Phosphorous(P_2O_5)	710	100-300	High
Potassium (K_2O)	4500	813-1355	High
Calcium (Ca)	6000	6929-8662	Low
Magnesium (Mg)	1500	692-1385	High
Sulfate (SO_4-S)	210	100-200	High
Sodium (Na)	370	< 250	See SAR
Chloride (Cl)	600	1-100	High
ECe (dS/m)	1.8	0.2-4	OK
Copper (Cu)	1.1	1 +	OK
Zinc (Zn)	11	3 +	OK
Iron (Fe)	86	8 +	OK
Manganese (Mn)	11	4 +	OK
Boron (B)	2.1	1-4	OK
SAR	2.1	0-6	OK
CEC (meq/100gms)	29	10-20	OK
ESP (%)	2.8	0-10	OK
pHs Value	4.3	6.5-7.5	Low
Organic Matter (%)	31		

RECOMMENDATIONS
ALL VALUES lbs/acre 6" deep

100	Nitrogen (N)
0	Phosphorous (P_2O_5)
0	Potassium (K_2O)
0	Gypsum ($CaSO_4$)
6000	Lime ($CaCO_3$)
0	Dolomite ($CaCO_3$ & $MgCO_3$)
0	Sulfur

*Gypsum adds Ca and doesn't affect pH; Lime adds Ca and raises pH; Dolomite adds Ca & Mg & raises pH.

Lime Requirement:
Tons of 100% $CaCO_3$ Lime per Acre 6" deep
needed to raise pH of soil to:

pH 6.0 needs	1.7
pH 6.5 needs	2.2
pH 7.0 needs	2.7

Gypsum Requirement (needed for clay treatment)
3.9 tons per acre 6" deep
Gypsum helps the soil structure by "loosening" the soil

Data:			Method
NO_3-N	< 2	mg/Kg	KCl
NH_3-N	16	mg/Kg	KCl
P	160	mg/Kg	Olsen
SP	140	%	Sat
pHs	4.3	unit	Sat
ECe	1.8	dS/m	Sat
Ca	5.9	meq/L	Sat
Mg	4.0	meq/L	Sat
Na	4.6	meq/L	Sat
K	9.5	meq/L	Sat
Cl	6.1	meq/L	Sat
SO_4-S	2.3	meq/L	Sat
SAR	2.1	ratio	Calc
B	1.1	mg/Kg	CaCl2
Cu	0.57	mg/Kg	DTPA
Zn	5.4	mg/Kg	DTPA
Fe	43	mg/Kg	DTPA
Mn	5.7	mg/Kg	DTPA

Data:			Method
OrgMat	31	%	WalkBk
Org-C	18	%	WalkBk
SMP Bufffer pH	7.17	unit	SMP
GypReq	4.6	meq/100g	GypSol
Ca	3000	mg/Kg	NH_4OAc
Mg	730	mg/Kg	NH_4OAc
Na	190	mg/Kg	NH_4OAc
K	1900	mg/Kg	NH_4OAc

Cation Exchange Capacity (CEC) and Base Saturation Percentages

CEC	29	meq/100gm	Calc.
NH_3-N	0.4	% of CEC	Calc.
Ca	52.1	% of CEC	Calc.
Mg	21.1	% of CEC	Calc.
Na	2.8	% of CEC	Calc.
K	16.5	% of CEC	Calc.
H	7.1	% of CEC	Calc.

Lab Analyst: Mike Galloway

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Work Order #: 1020003
Account #: 11294
Date Received: Feb 1, 2021
Date Reported: Feb 9, 2021

Soil Report

Debora Supinski
1435 Stanton St
Alameda, CA 94501

Lab Number: 1020003-3/4
Project #/Name: None / None
Sample ID: Orchard

	Your Values (lbs/acre 6" deep)	Suggested Values	
Ammonia (NH_3-N)	6.4	10-50	Low
Nitrate (NO_3-N)	6.4	20-100	Low
Total Available N	13	75-150	Low
Phosphorous(P_2O_5)	270	100-300	OK
Potassium (K_2O)	970	634-1056	OK
Calcium (Ca)	6800	5401-6751	High
Magnesium (Mg)	1000	540-1080	OK
Sulfate (SO_4-S)	56	100-200	Low
Sodium (Na)	72	< 250	See SAR
Chloride (Cl)	31	1-100	OK
ECe (dS/m)	0.92	0.2-4	OK
Copper (Cu)	0.49	1 +	Low
Zinc (Zn)	2.1	3 +	Low
Iron (Fe)	11	8 +	OK
Manganese (Mn)	1.5	4 +	Low
Boron (B)	0.23	1-4	Low
SAR	0.36	0-6	OK
CEC (meq/100gms)	23	10-20	OK
ESP (%)	0.69	0-10	OK
pHs Value	7.0	6.5-7.5	OK
Organic Matter (%)	7.9		

RECOMMENDATIONS
ALL VALUES lbs/acre 6" deep

125	Nitrogen (N)
0	Phosphorous (P_2O_5)
0	Potassium (K_2O)
0	Gypsum ($CaSO_4$)
0	Lime ($CaCO_3$)
0	Dolomite ($CaCO_3$ & $MgCO_3$)
0	Sulfur

*Gypsum adds Ca and doesn't affect pH; Lime adds Ca and raises pH; Dolomite adds Ca & Mg & raises pH.

Lime Requirement:
Tons of 100% $CaCO_3$ Lime per Acre 6" deep needed to raise pH of soil to:

pH 6.0 needs	0.0
pH 6.5 needs	0.0
pH 7.0 needs	0.0

Gypsum Requirement (needed for clay treatment)
1.7 tons per acre 6" deep
Gypsum helps the soil structure by "loosening" the soil

Data:			Method
NO_3-N	3.2	mg/Kg	KCl
NH_3-N	3.2	mg/Kg	KCl
P	62	mg/Kg	Olsen
SP	67	%	Sat
pHs	7.0	unit	Sat
ECe	0.92	dS/m	Sat
Ca	7.1	meq/L	Sat
Mg	3.0	meq/L	Sat
Na	0.82	meq/L	Sat
K	0.87	meq/L	Sat
Cl	0.64	meq/L	Sat
SO_4-S	1.3	meq/L	Sat
SAR	0.36	ratio	Calc
B	0.11	mg/Kg	CaCl2
Cu	0.24	mg/Kg	DTPA
Zn	1.0	mg/Kg	DTPA
Fe	5.7	mg/Kg	DTPA
Mn	0.74	mg/Kg	DTPA

Data:			Method
OrgMat	7.9	%	WalkBk
Org-C	4.6	%	WalkBk
SMP Bufffer pH	7.27	unit	SMP
GypReq	1.9	meq/100g	GypSol
Ca	3400	mg/Kg	NH_4OAc
Mg	510	mg/Kg	NH_4OAc
Na	36	mg/Kg	NH_4OAc
K	400	mg/Kg	NH_4OAc

Cation Exchange Capacity (CEC) and Base Saturation Percentages

CEC	23	meq/100gm	Calc.
NH_3-N	0.1	% of CEC	Calc.
Ca	75.6	% of CEC	Calc.
Mg	19.0	% of CEC	Calc.
Na	0.7	% of CEC	Calc.
K	4.6	% of CEC	Calc.
H	0.0	% of CEC	Calc.

Lab Analyst: Mike Galloway

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Work Order #: 1020003
Account #: 11294
Date Received: Feb 1, 2021
Date Reported: Feb 9, 2021

Soil Report

Debora Supinski
1435 Stanton St
Alameda, CA 94501

Lab Number: 1020003-4/4
Project #/Name: None / None
Sample ID: Orchard-Root Zone

	Your Values (lbs/acre 6" deep)	Suggested Values	
Ammonia (NH_3-N)	6.6	10-50	Low
Nitrate (NO_3-N)	11	20-100	Low
Total Available N	17	75-150	Low
Phosphorous(P_2O_5)	410	100-300	High
Potassium (K_2O)	1300	790-1318	OK
Calcium (Ca)	8200	6737-8422	OK
Magnesium (Mg)	1400	673-1347	High
Sulfate (SO_4-S)	71	100-200	Low
Sodium (Na)	92	< 250	See SAR
Chloride (Cl)	39	1-100	OK
ECe (dS/m)	1.0	0.2-4	OK
Copper (Cu)	0.65	1 +	Low
Zinc (Zn)	3.5	3 +	OK
Iron (Fe)	13	8 +	OK
Manganese (Mn)	0.91	4 +	Low
Boron (B)	0.38	1-4	Low
SAR	0.37	0-6	OK
CEC (meq/100gms)	28	10-20	OK
ESP (%)	0.71	0-10	OK
pHs Value	7.0	6.5-7.5	OK
Organic Matter (%)	8.9		

RECOMMENDATIONS
ALL VALUES lbs/acre 6" deep

125	Nitrogen (N)
0	Phosphorous (P_2O_5)
0	Potassium (K_2O)
0	Gypsum ($CaSO_4$)
0	Lime ($CaCO_3$)
0	Dolomite ($CaCO_3$ & $MgCO_3$)
0	Sulfur

*Gypsum adds Ca and doesn't affect pH; Lime adds Ca and raises pH; Dolomite adds Ca & Mg & raises pH.

Lime Requirement:
Tons of 100% $CaCO_3$ Lime per Acre 6" deep needed to raise pH of soil to:

pH 6.0 needs	0.0
pH 6.5 needs	0.0
pH 7.0 needs	0.0

Gypsum Requirement (needed for clay treatment)
1.8 tons per acre 6" deep
Gypsum helps the soil structure by "loosening" the soil

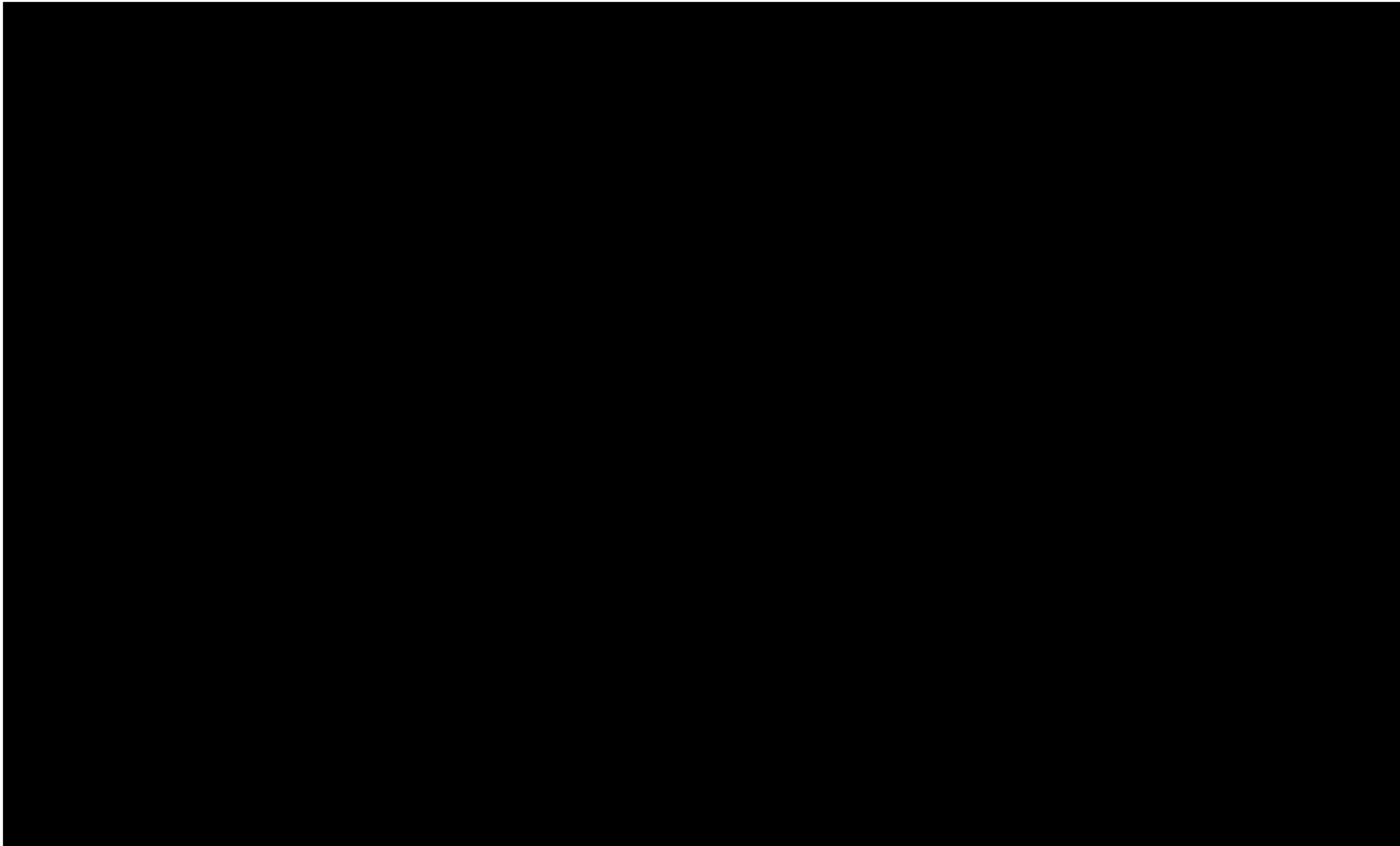
Data:			Method
NO_3-N	5.3	mg/Kg	KCl
NH_3-N	3.3	mg/Kg	KCl
P	92	mg/Kg	Olsen
SP	67	%	Sat
pHs	7.0	unit	Sat
ECe	1.0	dS/m	Sat
Ca	7.7	meq/L	Sat
Mg	3.9	meq/L	Sat
Na	0.89	meq/L	Sat
K	0.84	meq/L	Sat
Cl	0.81	meq/L	Sat
SO_4-S	1.7	meq/L	Sat
SAR	0.37	ratio	Calc
B	0.19	mg/Kg	CaCl2
Cu	0.32	mg/Kg	DTPA
Zn	1.8	mg/Kg	DTPA
Fe	6.3	mg/Kg	DTPA
Mn	0.45	mg/Kg	DTPA

Data:			Method
OrgMat	8.9	%	WalkBk
Org-C	5.2	%	WalkBk
SMP Bufffer pH	7.29	unit	SMP
GypReq	2.1	meq/100g	GypSol
Ca	4100	mg/Kg	NH_4OAc
Mg	710	mg/Kg	NH_4OAc
Na	46	mg/Kg	NH_4OAc
K	540	mg/Kg	NH_4OAc

Cation Exchange Capacity (CEC) and Base Saturation Percentages

CEC	28	meq/100gm	Calc.
NH_3-N	0.1	% of CEC	Calc.
Ca	73.2	% of CEC	Calc.
Mg	21.0	% of CEC	Calc.
Na	0.7	% of CEC	Calc.
K	4.9	% of CEC	Calc.
H	0.0	% of CEC	Calc.

Lab Analyst: Mike Galloway



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COMET-Planner Carbon Sequestration and Greenhouse Gas Estimation Report

Project Name: [redacted] CFP Current

State: California

County: Contra Costa

Date Created: 06/14/2022 21:17:48

Note: Acreages were multiplied by a factor of 100 to prevent rounding in COMET-PLANNER and arrive at accurate sequestration values.

Approximate Carbon Sequestration and Greenhouse Gas Emission Reductions*
(tonnes CO_2 equivalent per year)

NRCS Conservation Practices	Acres	Carbon Dioxide	Nitrous Oxide	Methane	Total CO_2-Equivalent
Residue and Tillage Management - No-Till (CPS 329) - Reduced Till to No Till or Strip Till on Irrigated Cropland	71	19	1	0	20
Cover Crop (CPS 340) - Add Legume Seasonal Cover Crop (with 50% Fertilizer N Reduction) to Irrigated Cropland	71	84	-19	0	65
Mulching (CPS 484) - Add Mulch to Croplands	71	15	0	N.E.**	15
Hedgerow Planting (CPS 422) - Replace a Strip of Cropland with 1 Row of Woody Plants	5	41	1	N.E.**	42
Totals:	218	159	-17	0	142

*Negative values indicate a loss of carbon or increased emissions of greenhouse gases
**Values were not estimated due to limited data on reductions of greenhouse gas emissions from this practice

For more information on how these estimates were generated, please visit www.comet-planner.com.

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COMET-Planner Carbon Sequestration and Greenhouse Gas Estimation Report

Project Name: [redacted] CFP

State: California

County: Contra Costa

Date Created: 06/14/2022 21:01:18

Note: Acreages were multiplied by a factor of 100 to prevent rounding in COMET-PLANNER and arrive at accurate sequestration values.

Approximate Carbon Sequestration and Greenhouse Gas Emission Reductions*
(tonnes CO_2 equivalent per year)

NRCS Conservation Practices	Acres	Carbon Dioxide	Nitrous Oxide	Methane	Total CO_2-Equivalent
Residue and Tillage Management - No-Till (CPS 329) - Reduced Till to No Till or Strip Till on Irrigated Cropland	102	27	2	0	29
Cover Crop (CPS 340) - Add Legume Seasonal Cover Crop (with 50% Fertilizer N Reduction) to Irrigated Cropland	102	121	-28	0	93
Mulching (CPS 484) - Add Mulch to Croplands	102	21	0	N.E.**	21
Conservation Cover (CPS 327) - Convert Non-Irrigated Cropland to Permanent Unfertilized Grass/Legume Cover	38	20	0	0	20
Riparian Herbaceous Cover (CPS 390) - Convert Non-Irrigated Cropland to Permanent Unfertilized Grass/Legume Cover Near Aquatic Habitats	5	3	0	0	3
Hedgerow Planting (CPS 422) - Replace a Strip of Cropland with 1 Row of Woody Plants	33	272	9	N.E.**	281
Totals:	382	464	-17	0	447

*Negative values indicate a loss of carbon or increased emissions of greenhouse gases
**Values were not estimated due to limited data on reductions of greenhouse gas emissions from this practice

For more information on how these estimates were generated, please visit www.comet-planner.com.


[redacted] Current Climate Smart Agriculture Management Practices
Created by Ben Weise, June 2022
Contra Costa Resource Conservation District
Legend
Cover Crop/Mulching/Compost Application/Reduced Tillage
Hedgerow
N
100 ft
Google Earth

TOC


[redacted] Recommended Climate Smart Agriculture Management Practices
Created by Ben Weise, June 2022
Contra Costa Resource Conservation District
Legend
Conservation Cover
Cover Crop/Mulch/Compost Application/Reduced Tillage
Development (Buildings)
Hedgerow
Riparian Herbaceous Cover
N
100 ft
Google Earth

Appendix I. Recommended NRCS Conservation Practice Standards

The following are recommended management practices under the [redacted] Carbon Farm Plan. We have included relevant NRCS Conservation Practice Standard sheets that provide additional detail and information on each practice. For further information, please contact the Contra Costa Resource Conservation District of the USDA NRCS - Concord Field Office.

- NRCS CPS 327 - Conservation Cover
- NRCS CPS 329 - Residue and Tillage Management - No Till
- NRCS CPS 340 - Cover Crop
- NRCS CPS 390 - Riparian Herbaceous Cover
- NRCS CPS 422 - Hedgerow Planting
- NRCS CPS 484 - Mulching
- NRCS CPS 808 - Soil Carbon Amendment (Draft)

United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

CONSERVATION COVER

CODE 327

(ac)

DEFINITION

Establishing and maintaining permanent vegetative cover

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Reduce sheet, rill, and wind erosion and sedimentation
- Reduce ground and surface water quality degradation by nutrients and surface water quality degradation by sediment
- Reduce emissions of particulate matter (PM), PM precursors, and greenhouse gases.)
- Enhance wildlife, pollinator and beneficial organism habitat
- Improve soil health

CONDITIONS WHERE PRACTICE APPLIES

This practice applies on all lands needing permanent herbaceous vegetative cover. This practice does not apply to plantings for forage production or to critical area plantings. This practice can be applied on a portion of the field.

CRITERIA

General Criteria Applicable to All Purposes

Select species that are adapted to the soil, ecological sites, and climatic conditions that are suitable for the planned purpose and site conditions. Periodic removal of some products such as high value trees, medicinal herbs, nuts, and fruits is permitted provided the conservation purpose is not compromised by the loss of vegetation or harvesting disturbance.

Species planted shall be suitable for the planned purpose and site conditions. Refer to CA eVegGuide for approved species for the practice and site.

Inoculate legumes at planting time.

Choose seeding rates and planting methods that will be adequate to accomplish the planned purpose.

Planting dates, planting methods and care in handling and planting of the seed or planting stock shall ensure that planted materials have an acceptable rate of survival. Vegetative planting material (e.g. sprigs, rhizomes, bulbs) shall be from a reliable supplier.

Prepare the site by establishing a consistent seeding depth. Eliminate weeds that would impede the establishment and growth of selected species.

Base the timing and equipment selection on the site and soil conditions.

Apply nutrients as needed to ensure crop establishment and planned growth.

Do not plant species listed by the state as a noxious weed or invasive plant. For a list of invasive species refer to the county Weed Management Area lists or CALIPC 2006 Invasive Plant Inventory for species with an overall rating of HIGH

Do not plant species that are known to host crop pests for crops grown nearby.

The practice shall be protected from livestock grazing and trampling to the extent necessary to ensure that it will perform the intended purpose(s).

Additional Criteria to Reduce Sheet, Rill, and Wind Erosion and Sedimentation

Determine and maintain the amount of plant biomass and cover needed to reduce wind and water erosion to the planned soil loss objective by using the current approved wind and/or water erosion prediction technology.

Additional Criteria to Reduce Emissions of Particulate Matter (PM), PM Precursors, and green-house gases

In perennial crop systems such as orchards, vineyards, berries and nursery stock, establish vegetation to provide full ground coverage in the alleyway during mowing and harvest operations to minimize generation of particulate matter.

Additional Criteria to Enhance Wildlife, Pollinator and Beneficial Organism Habitat

Plant a diverse mixture grasses and forbs species to promote bio-diversity and meet the needs of the targeted species using approved habitat appraisal guides, evaluation tools, and appraisal worksheets for the respective state.

Locate habitat plantings to reduce pesticide exposures that could harm wildlife, pollinators, and other beneficial organisms.

Additional Criteria to Improve Soil Health

To maintain or improve soil organic matter, select plants that will produce high volumes of organic material. The amount of biomass needed will be determined using the current soil conditioning index procedure.

CONSIDERATIONS

This practice may be used to promote the conservation of wildlife species in general, including threatened and endangered species.

Certified seed and planting stock that is adapted to the site should be used when it is available.

Mowing may be needed during the establishment period to reduce competition from weeds.

On sites where annual grasses are an expected weed problem it may be necessary to postpone nitrogen fertilizer application until the planted species are well established.

Unless soil fertility severely degraded, when establishing natives, nutrient applications may not be advisable since they can encourage non-native plant competition.

Where applicable this practice may be used to conserve and stabilize archeological and historic sites.

Consider rotating management and maintenance activities (e.g. mow only one- fourth or one-third of the area each year) throughout the managed area to maximize spatial and temporal diversity.

TOC

Where wildlife management is an objective, the food and cover value of the planting can be enhanced by using a habitat evaluation procedure to aid in selecting plant species and by providing or managing for other habitat requirements necessary to achieve the objective. Encouraging plant species diversity and establishing plantings that result in multiple structural levels of vegetation within the conservation cover will maximize wildlife use.

Where pollinator and wildlife habitat are primary purposes consider less dense seeding rates as long as soil loss is within tolerable soil loss limits.

To provide habitat for natural enemies of crop pests, select a mix of plant species that provide year round habitat and food (accessible pollen or nectar) for the desired beneficial species. Consider habitat requirements of predatory and parasitic insects, spiders, insectivorous birds and bats, raptors, and terrestrial rodent predators.

Consult Land Grant University Integrated Pest Management recommendations for beneficial habitat plantings to manage the target pest species.

Use a diverse mix of cover plant species that come into bloom at different times and provide a sequence of bloom throughout the year [e.g., plant at least three flowering species from each of the three bloom periods (spring, summer, and fall)].

Where practical, use native species that are appropriate for the identified resource concern and management objective. Consider trying to re-establish the native plant community for the site.

If a native cover (other than what was planted) establishes, and this cover meets the intended purpose and the landowner's objectives, the cover should be considered adequate.

During vegetation establishment, natural mulches such as wood products, straw, or hay, can be used to conserve soil moisture, support beneficial soil life, and suppress competing vegetation.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for the site to include, but are not limited to:

- recommended species,
- seeding rates and dates,
- establishment procedures,
- management actions needed to insure and adequate stand

Specifications and operation and maintenance shall be recorded using approved Implementation Requirement document.

OPERATION AND MAINTENANCE

Mowing and harvest operations in a perennial crop system such as orchards, vineyards, berries, and nursery stock shall be done in a manner which minimizes the generation of particulate matter.

If wildlife habitat enhancement is a purpose, maintenance practices and activities shall not disturb cover during the reproductive period for the desired species. Exceptions should be considered for periodic burning or mowing when necessary to maintain the health of the plant community.

Control noxious weeds and other invasive species.

Mowing may be needed during the establishment period to reduce competition from weeds.

To benefit insect food sources for grassland nesting birds, spraying or other control of noxious weeds shall be done on a "spot" basis to protect forbs and legumes that benefit native pollinators and other wildlife.

Re-vegetate bare spots when the purpose is not adequately addressed.

REFERENCES

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Preventing or mitigating potential negative impacts of pesticides on pollinators using IPM and other conservation practices. Nat. Agron. Tech Note 9. Washington, DC. http://directives.sc.egov.usda.gov/

USDA United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

RESIDUE AND TILLAGE MANAGEMENT, NO TILL

CODE 329

(ac)

DEFINITION

Limiting soil disturbance to manage the amount, orientation, and distribution of crop and plant residue on the soil surface year around.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Reduce sheet, rill and wind erosion, and excessive sediment in surface waters.
- Reduce tillage-induced particulate emissions.
- Maintain or increase soil health and organic matter content.
- Increase plant-available moisture.
- Reduce energy use.
- Provide food and escape cover for wildlife.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all cropland.

CRITERIA

General Criteria Applicable to All Purposes

Residue shall not be burned.

Distribute all residues uniformly over the entire field. Removing residue from directly within the seeding or transplanting area prior to or as part of the planting operation is acceptable.

This practice only involves an in-row soil disturbance operation during strip tillage, the planting operation, and a seed row/furrow closing device. There is no full-width soil disturbance performed from the time immediately following harvest or termination of one cash crop through harvest or termination of the next cash crop in the rotation regardless of the depth of the tillage operation. The soil tillage intensity rating (STIR) value shall include all field operations that are performed during the crop interval between harvest and termination of the previous cash crop and harvest or termination of the current cash crop (includes fallow periods). The crop interval STIR value shall be no greater than 20.

Additional Criteria to Reduce Sheet, Rill and Wind Erosion, Reduce Excessive Sediment in Surface Waters, and Reduce Tillage-Induced Particulate Emissions

Use the current approved water and wind erosion prediction technology to determine the if field operations planned provide the amount of randomly distributed surface residue needed, time of year residue needs to be present in the field, and amount of surface soil disturbance allowed to reduce erosion to the desired level. Calculations shall account for the effects of other practices in the management system.

TOC

Additional Criteria to Maintain or Increase Soil Health and Organic Matter Content

Ensure the soil condition index (SCI) for the cropping system results in a positive rating.

Additional Criteria to Increase Plant-Available Moisture

Maintain a minimum of 60 percent residue cover on the soil surface throughout the year.

Trapping snow

Minimum crop stubble height during the time significant snowfall is expected to occur shall be—

- At least 10 inches for crops with a row spacing of less than 15 inches.
- At least 15 inches for crops with a row spacing of 15 inches or greater.

Additional Criteria to Reduce Energy Use

Reduce the total energy consumption associated with field operations by at least 25 percent compared to the benchmark condition. Use the current approved NRCS tool for determining energy use to document energy use reductions.

Additional Criteria to Provide Food and Escape Cover for Wildlife

Use an approved habitat evaluation procedure to determine when residue needs to be present, and the amount, orientation, and stubble height needed to provide adequate food and cover for target species.

CONSIDERATIONS

General Considerations

Removal of crop residue, such as by baling or grazing, can have a negative impact on resources. These activities should not be performed without full evaluation of impacts on soil, water, animal, plant, and air resources.

Production of adequate crop residues to achieve the purpose(s) of this practice can be enhanced through the use of high residue crops and crop varieties, use of cover crops, double cropping, and adjustment of plant populations through seeding rates and row spacing.

When providing technical assistance to organic producers, ensure residue and tillage management, activities are consistent with the USDA Agricultural Marketing Service National Organic Program regulations.

Residue should not be shredded after harvest. Shredding residue makes it more susceptible to movement by wind or water, and areas where residue accumulates may interfere with planting the next crop.

Using residue management - no till for all crops in the rotation or cropping system can enhance the positive effects of this practice by—

- Increasing the rate of soil organic matter accumulation.
- Keeping soil in a consolidated condition and improved aggregate stability.
- Sequestering additional carbon in the soil.
- Further reducing the amount of particulate matter generated by field operations.
- Reduce energy inputs to establish crops.
- Forming root channels and other near-surface voids that increase infiltration.

Considerations to Increase Soil Health and Organic Matter Content

Carbon loss is directly related to the volume of soil disturbed, intensity of the disturbance and soil moisture content and soil temperature at the time the disturbance occurs. To make this practice more effective—

- When deep soil disturbance is performed, such as by subsoiling or fertilizer injection, make sure the vertical slot created by these implements is closed at the surface.
- Planting with a single disk or slot opener no-till drill will release less CO_2 and oxidize less organic matter than planting with a wide-point hoe/chisel opener seeder drill.
- Soil disturbance that occurs when soil temperatures are below 50 °F will oxidize less organic matter and release less CO_2 than operations done when the soil is warmer.
- Maximizing year-round coverage of the soil with living vegetation (e.g., cover crops) and crop residues, if applicable, builds organic matter and reduces soil temperature, thereby slowing organic matter oxidation.
- Use a diverse crop rotation, incorporating multiple crop types (cool-season grass, cool-season legume/forb, warm-season grass, warm-season legume/forb) into the crop rotation.
- Plant a cover crop after every cash crop in the rotation. Multispecies cover crop mixes provide greater benefits than single-specie cover crops.

Considerations to Increase Plant-Available Moisture

Leaving stubble taller than the 10-inch minimum will trap more snow.

Variable-height stubble patterns may be created to further increase snow storage.

Performing all field operations on the contour will slow overland flow and allow more opportunity for infiltration.

Considerations for Wildlife Food and Cover

Leaving rows of unharvested crop standing at intervals across the field or adjacent to permanent cover will enhance the value of residues for wildlife food and cover. Leaving unharvested crop rows for two growing seasons will further enhance the value of these areas for wildlife.

Leave crop residues undisturbed after harvest (e.g., no shredding or baling) to maximize the cover and food source benefits for wildlife.

PLANS AND SPECIFICATIONS

Specifications for establishment and operation of this practice shall be prepared for each field or treatment unit. Record the specifications using the practice implementation requirements document. The specifications shall identify, as appropriate, the—

- Purpose for applying the practice.
- Planned crops.
- Amount of residue produced by each crop.
- All field operations or activities that affect the—
  - Residue orientation including height (where applicable).
  - Surface disturbance.
  - Amount of residue (pounds/acre or percent surface cover) required to accomplish the purpose, and the time of year it must be present.
- Planned soil tillage intensity rating STIR value, soil condition index value, and erosion rate.
- Target species of wildlife, if applicable.
- Benchmark and planned fuel consumption, if applicable.

OPERATION AND MAINTENANCE

Evaluate/measure the crop residues cover and orientation after each crop to ensure the planned amounts and orientation are being achieved. Adjust management as needed to either plan a new residue amount and orientation or adjust the planting equipment, and if applicable, the harvesting equipment.

TOC

Limited tillage is allowed to close or level ruts from harvesting equipment. No more than 10 percent of the field may be tilled for this purpose.

If there are areas of heavy residue accumulation (because of movement by water or wind) in the field, spread the residue prior to planting so it does not interfere with planter operation.

REFERENCES

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United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

COVER CROP

CODE 340

(ac)

DEFINITION

Crops including grasses, legumes, and forbs for seasonal cover and other conservation purposes.

PURPOSE

This practice is applied to support one or more of the following purposes:

- Reduce erosion from wind and water.
- Increase soil organic matter content.
- Capture and recycle or redistribute nutrients in the soil profile.
- Promote biological nitrogen fixation and reduce energy use.
- Increase biodiversity.
- Suppress Weeds.
- Manage soil moisture.
- Minimize and reduce soil compaction.

CONDITIONS WHERE PRACTICE APPLIES

All lands requiring seasonal vegetative cover for natural resource protection and or improvement. This practice does not apply to plantings for forage production.

CRITERIA

General Criteria Applicable to All Purposes

Plant species, seedbed preparation, seeding rates, seeding dates, seeding depths, fertility requirements, and planting methods will be consistent with approved local criteria and site conditions.

The species selected will be compatible with other components of the cropping system.

Ensure herbicides used with cover crops are compatible with the following crop.

Do not burn cover crop residue.

On non-irrigated cropland, cover crop termination must be at or before the time period specified in *NRCS Cover Crop Termination Guidelines –*

Non-Irrigated Cropland. The guideline is located in the Cover Crop folder in section IV of the Field Office Technical Guide.

The cover crop cannot be harvested as a cash crop, but closely-managed grazing is allowed as long as the purpose(s) of the practice are met.

Additional Criteria to Reduce Erosion from Wind and Water

Time cover crop establishment in conjunction with other practices, so that the soil will be adequately protected during the critical erosion period(s).

Plants selected for cover crops will have the physical characteristics necessary to provide adequate protection.

Determine the amount of surface and/or canopy cover needed from the cover crop using current erosion prediction technology.

Additional Criteria to Maintain or Increase Soil Health and Organic Matter Content

Cover crop species will be selected on the basis of producing high volumes of organic material and or root mass to maintain or improve soil organic matter.

The NRCS Soil Conditioning Index (SCI) procedure will be used to determine the amount of biomass required to have a positive trend in the soil organic matter subfactor.

The cover crop shall be planted plant as early as possible and be terminated as late as feasible to maximize plant biomass production, considering crop insurance criteria, the time needed to prepare the field for planting the next crop, and soil moisture depletion.

Additional Criteria to Capture and RecycleExcess Nutrients in the Soil Profile

Cover crops will be established and actively growing before the expected period(s) of nutrient leaching.

Select cover crop species for their ability to take up large amounts of nutrients from the rooting profile of the soil.

Terminate the cover crop as late as feasible to maximize nutrient uptake. Consider the time needed to prepare the field for planting the next crop and soil moisture depletion.

Additional Criteria to Promote BiologicalNitrogen Fixation and Reduce Energy Use

Use legumes or legume-grass mixtures to establish cover crops.

The specific Rhizobium bacteria for the selected legume will either be present in the soil or the seed will be inoculated at the time of planting.

Additional Criteria to Increase Biodiversity

Select cover crop species to achieve one or more of the following: species mix with different maturity dates, attract beneficial insects, attract pollinators, increase soil biological diversity, serve as a trap crop for damaging insects, and/or provide food and cover for wildlife habitat management.

Additional Criteria for Weed Suppression

Species for the cover crop will be selected for their chemical or physical characteristics to suppress or compete with weeds.

Higher seeding rates to provide additional cover will help control weeds to eliminate or reduce herbicide use.

Cover crops residues will be left on the soil surface to maximize allelopathic (chemical) and mulching (physical) effects.

A late kill may be used if the objectives are to use as a biocontrol.

For long-term weed suppression, reseeding annuals and/or biennial species can be used.

Additional Criteria for Soil MoistureManagement

Terminate growth of the cover crop sufficiently early to conserve soil moisture for the subsequent crop. Cover crops established for moisture conservation shall be left on the soil surface.

In areas of potential excess soil moisture, allow the cover crop to grow as long as possible to maximize soil moisture removal.

Additional Criteria to Minimize and ReduceSoil Compaction

Select and manage cover crop species that will produce deep roots and large amounts of surface or root biomass to increase soil organic matter, improve soil structure, and increase soil moisture through better infiltration.

CONSIDERATIONS

General Considerations

Plant cover crops in a timely matter to establish a good stand.

When applicable, ensure cover crops are managed and are compatible with the client's crop insurance criteria.

Maintain an actively growing cover crop as late as feasible to maximize plant growth, allowing time to prepare the field for the next crop and moisture depletion.

When used to redistribute nutrients from deeper in the profile up to the surface layer, consider killing of the cover crop in relation to the planting date of the following crop.

If the objective is to best synchronize the use of cover crop as a green manure to cycle nutrients, factors such as the carbon/nitrogen ratios may be considered to kill early and have a faster mineralization of nutrients to match release of nutrient with uptake by following cash crop.

The right moment to kill the cover crop will depend on the specific rotation, weather, and grower objectives.

Use deep-rooted species to maximize nutrient recovery.

Use grasses to utilize more soil nitrogen, and legumes utilize both nitrogen and phosphorus.

Avoid cover crop species that harbor or carryover potentially damaging diseases or insects.

For most purposes for which cover crops are established, the combined canopy and surface cover is at nearly 90 percent or greater, and the above ground (dry weight) biomass production is at least 4,000 lbs/acre.

Cover crops may be used to improve site conditions for establishment of perennial species.

Use plant species that enhance bio-fuels opportunities.

Use plant species that enhance forage opportunities for pollinators by using diverse legumes and other forbs.

Use a diverse mixture of 2 or more species to address multiple purposes.

PLANS AND SPECIFICATIONS

Plans and specifications will be prepared for the practice site. Plans for the establishment of cover crops shall include:

- Field number and acres
- Species or species of plants to be established.
- Seeding rates.
- Recommended seeding dates.
- Establishment procedure.
- Planned rates and timing of nutrient application.
- Planned dates and method to terminate the cover crop.
- Other information pertinent to establishing and managing the cover crop.

Plans and specifications for the establishment and management of cover crops may be recorded in narrative form, on job sheets, or on other forms.

OPERATION AND MAINTENANCE

Control growth of the cover crop to reduce competition from volunteer plants and shading.

Control weeds in cover crops by mowing or by using other pest management techniques.

Control soil moisture depletion by selecting water efficient plant species and terminating the cover crop before excessive transpiration.

Evaluate the cover crop to determine if the cover crop is meeting the planned purpose(s). If the cover crop is not meeting the purpose(s) adjust the management, change the species of cover crop, or choose a different technology.

REFERENCES

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USDA United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

RIPARIAN HERBACEOUS COVER

CODE 390

(ac)

DEFINITION

Grasses, sedges, rushes, ferns, legumes, and forbs tolerant of intermittent flooding or saturated soils, established or managed as the dominant vegetation in the transitional zone between upland and aquatic habitats.

PURPOSE

This practice is used to accomplish one or more of the following purposes–

- Provide or improve food and cover for fish, wildlife and livestock,
- Improve and maintain water quality
- Establish and maintain habitat corridors
- Increase water storage on floodplains
- Reduce erosion and improve stability to stream banks and shorelines
- Increase net carbon storage in the biomass and soil
- Enhance pollen, nectar, and nesting habitat for pollinators
- Restore, improve or maintain the desired plant communities
- Dissipate stream energy and trap sediment
- Enhance stream bank protection as part of stream bank soil bioengineering practices

CONDITIONS WHERE PRACTICE APPLIES

- Areas adjacent to perennial and intermittent watercourses or water bodies where the natural plant community is dominated by herbaceous vegetation that is tolerant of periodic flooding or saturated soils. For seasonal or ephemeral watercourses and water bodies, this zone extends to the center of the channel or basin.
- Where channel and stream bank stability is adequate to support this practice.
- Where the riparian area has been altered and the potential natural plant community has changed.

CRITERIA

General Criteria Applicable to All Purposes

Where available, use Ecological Site Description to guide restoration to appropriate vegetative community phase and include appropriate vegetative functional groups.

Select perennial plants that are adapted to site and hydrologic conditions and provide the structural and functional diversity preferred by fish and wildlife likely to benefit from the installation of the practice. Select from those species found in the California Vegetation Guide specific to that MLRA for the site. In areas where native seeds and propagules are present, natural regeneration can be used in lieu of planting. Planting is required if no native seed bank is present.

Protect riparian vegetation and water quality by reducing or excluding haying and grazing until the desired plant community is well established.

Stream type and site hydrology must be considered. Selected plant species must be adapted to the projected duration of saturation and inundation of the site.

Harmful pests present on the site will be controlled or eliminated as necessary to achieve and maintain the intended purpose.

Pest management will be conducted in a manner that mitigates impacts to pollinators.

Management systems applied will be designed to maintain or improve the vigor and reproduction of the desired plant community.

Timing of haying or grazing periods will avoid periods when streambanks are vulnerable to livestock or mechanical damage.

Necessary site preparation and planting shall be done at a time and manner to insure survival and growth of selected species. Only viable, high quality and site-adapted planting stock will be used.

Determine the width of the riparian herbaceous cover planting based on the geomorphic potential of the site and project purposes, including the life history requirements of local fish and wildlife species, including pollinators.

Existing underground functional drains that pass through these areas shall be replaced with rigid, non perforated pipe through the buffer or equipped with a management regulating structure to allow control of overflow.

Domestic grazing should be deferred for a minimum of two years or until such time as the desired plant community is established.

Additional Criteria to Maintain or Improve Water Quality and Quantity

Minimum width shall be increased to 2.5 times the stream width (based on the horizontal distance between bank-full elevations) or 35 feet for water bodies. Concentrated flow erosion or mass soil movement shall be controlled in the up gradient area prior to establishment of the riparian herbaceous cover.

Species selected shall have stiff stems and high stem density near the ground surface to reduce water velocities and facilitate infiltration into the floodplain.

Additional Criteria to Stabilize Streambanks and Shorelines

Select native or accepted, introduced species that provide a deep, binding root mass to strengthen streambanks and improve soil health.

Additional Criteria for Increasing Net Carbon Storage in Biomass and Soils

Maximize width and length of the herbaceous riparian cover to fit the site.

Plant species used will have the highest rates of biomass production for the soil and other site conditions, consistent with meeting fish and wildlife habitat requirements.

Additional Criteria for Pollinator Habitat

Include forbs and legumes that provide pollen and nectar for native bees. Utilize a diverse mix of plant species that bloom at different times throughout the year.

TOC

Additional Criteria for Terrestrial Wildlife

Select native species adapted to the site.

Density of the vegetative stand established for this purpose shall be managed for targeted wildlife habitat requirements and shall encourage plant diversity.

If mowing is necessary to maintain herbaceous cover it will occur outside the nesting and fawning season and allow for adequate re- growth for winter cover. To protect pollinators and maintain habitat with a diversity of plant structure, a third or less of the site should be disturbed (mowed, grazed, burned, etc.) each year, allowing for recolonization of pollinators from surrounding habitat.

The management plan shall consider habitat and wildlife objectives such as habitat diversity, habitat linkages, daily and seasonal habitat ranges, limiting factors and native plant communities.

Additional Criteria for Restoring Desired Plant Community

Use Ecological Site Description (ESD) State and Transition models, where available, to determine if proposed actions are ecologically sound and defensible. Treatments need to be congruent with dynamics of the ecological site(s) and keyed to states and plant community phases that have the potential and capability to support the desired plant community. If an ESD is not available, base design criteria on best approximation of the desired plant community composition, structure, and function.

CONSIDERATIONS

Selection of native plant species is preferred. All selected species should have multiple values such as those suited for biomass, wintering and nesting cover, aesthetics, forage value for aquatic invertebrates, and tolerance to locally used herbicides.

Other conservation practices that may facilitate the establishment of Riparian Herbaceous Cover or enhance its performance include:

- Stream Habitat Improvement and Management - (395)
- Streambank and Shoreline Protection – (580)
- Fence – (382)
- Forage and Biomass Planting – (512)
- Range Planting – (550)
- Filter Strip – (393)
- Access Control – (472)
- Prescribed Grazing – (528)
- Brush Management – (314)
- Herbaceous Weed Control – (315)
- Heavy Use Area Protection (561)
- Critical Area Planting (342)
- Riparian Forest Buffer (391)
- Early Successional Habitat Development and Management - (643)
- Conservation Cover - (327)
- Restoration and Management of Rare and Declining Habitat - (647)
- Stream Crossing (578)
- Watering Facility (614)

Considerations should be given to how this practice will complement the functions of adjacent riparian, terrestrial and aquatic habitats.

Consider the effects of upstream and downstream conditions, structures, facilities, and constraints on the planned activities.

Control of invasive trees and shrubs may be required to prevent dominance of the riparian zone by woody plants and maintain openness in riparian system.

Establish alternative water sources or controlled access stream crossings to manage livestock access to the stream and riparian area.

Selection of native plant species is recommended. Introduced species may be used under certain conditions. Introduced species already present in the watershed may be used when native seed or plugs are unavailable or won't establish. All selected species should have multiple values such as those suited for biomass, wintering and nesting cover, aesthetics, forage value for aquatic invertebrates, and tolerance to locally used herbicides.

Herbaceous riparian areas can function to link pollinators with adjacent fragmented habitat, and can serve as a conduit to move pollinators into areas requiring insect pollination. Different flower sizes and shapes appeal to different categories of pollinators. To support many species, consider establishing the greatest diversity possible. Consider incorporating nesting habitat, including patches of unshaded bare soil for ground nesting bees or where bumble bee conservation is a priority, clump forming warm-season native grasses.

Avoid plant species which may be alternate hosts to pests. Species diversity should be considered to avoid loss of function due to species-specific pests.

The location, layout and vegetative structure and composition of the buffer should complement natural features.

Corridor configuration, establishment procedures and management should enhance habitats for threatened, endangered and other plant or animal species of concern, where applicable.

Use plant species that provide full ground coverage to reduce particulate matter generation during establishment and maintenance operations.

PLANS AND SPECIFICATIONS

Specifications for this practice shall be prepared for each site. Specification shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

OPERATION AND MAINTENANCE

The purpose of operation, maintenance and management is to insure that the practice functions as intended over time.

The riparian area will be inspected periodically in order to detect adverse impacts and make adjustments in management to maintain the intended purpose.

Control of concentrated flow erosion or mass soil movement shall be continued in the up- gradient area to maintain riparian function.

Any use of fertilizers, pesticides and other chemicals to assure riparian area function shall not compromise the intended purpose.

Harmful pests present on the site will be controlled or eliminated as necessary to achieve and maintain the intended purpose.

Pest management will be conducted in a manner that mitigates impacts to pollinators.

Avoid haying or grazing when streambanks and riparian areas are vulnerable to livestock or mechanical damage.

Manage grazing to sustain riparian functions and values.

Management systems will be designed and applied to maintain or improve the vigor and reproduction of the desired plant community, e.g., the riparian functions and values.

Where the primary purpose of the practice is to provide terrestrial wildlife habitat, the density of the vegetative stand shall be managed for targeted wildlife habitat requirements and shall encourage plant diversity. If mowing is necessary to maintain herbaceous cover, it will occur outside the nesting and fawning season and allow for adequate re-growth for winter cover.

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USDA United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

HEDGEROW PLANTING

CODE 422

(ft)

DEFINITION

Establishment of dense vegetation in a linear design to achieve a natural resource conservation purpose.

PURPOSE

Providing at least one of the following conservation functions:

- Habitat, including food, cover, and corridors for terrestrial wildlife
- To enhance pollen, nectar, and nesting habitat for pollinators
- Food, cover, and shade for aquatic organisms that live in adjacent streams or watercourses
- To provide substrate for predaceous and beneficial invertebrates as a component of integrated pest management
- To intercept airborne particulate matter
- To reduce chemical drift and odor movement
- Screens and barriers to noise and dust
- To increase carbon storage in biomass and soils
- Living fences
- Boundary delineation and contour guidelines

CONDITIONS WHERE PRACTICE APPLIES

This practice applies wherever it will accomplish at least one of the purposes stated above.

CRITERIA

General Criteria Applicable to All Purposes

Hedgerows shall be established using woody plants or perennial bunch grasses producing erect stems attaining average heights of at least 3 feet persisting over winter.

Plants selected must be suited and adapted to soil and site conditions, climate, and conservation purpose. Plants shall be selected off the CA e-Veg Guide.

No plant listed by the state as a noxious weed shall be established in a hedgerow.

Species shall be selected that do not host pests or diseases that could pose a risk to nearby crops. Refer to notes in the CA e-veg guide related to pest issues.

The practice shall be protected from livestock grazing and trampling to the extent necessary to ensure that it will perform the intended purpose(s).

Competing vegetation shall be controlled until the hedgerow becomes established. Control shall continue beyond the establishment period, if necessary.

All planned work shall comply with federal, state and local laws and regulations.

No minimum width beyond a single row is required except where wildlife food and cover is an objective. Single rows can be as narrow as five feet, but must be wide enough to address the purpose.

Up to five percent of plants may be species where fruits, nuts, berries or other plant materials are collected for their own personal consumption. Those plants shall not be disturbed until after those plants have met the purpose of providing for wildlife, pollinators, beneficial insects, screens, etc.

Additional Criteria for Wildlife Food, Cover and Corridors

At least 80 percent of plants shall be CA natives suitable for the MLRA planted in. Multiple species increase food and habitat diversity while reducing pest and disease risk.

Selected plants shall provide cover and/or food to support the landowner's wildlife objective

Minimum hedgerow width, at maturity, shall be 15 feet, unless wildlife species do not require such width for food, cover, shelter and the ability to safely move around. This may necessitate the establishment of more than one row of plants.

Additional Criteria for Pollinator Habitat

Hedgerow plants must provide abundant pollen and nectar resources.

Multiple species with different blooming periods (early spring through late summer) shall be included in the planting. The actual number of species is dependent upon the availability of adjacent flowering plants. Plants that bloom during the same period as adjacent insect-pollinated crops can be excluded.

Pollinator hedgerows will be protected from pesticides that may harm pollinators. If pest control is required, only non-blooming plants will be treated, and/or only pesticides non-toxic to pollinators shall be used.

Additional Criteria for Living Fences

Selected plants shall attain a size and density adequate to create a barrier to contain livestock or humans, as needed.

If the purpose is to contain livestock, selected plants shall not be poisonous or hazardous to the animals.

Additional Criteria for Boundary Delineation

Hedgerows shall be aligned along boundaries of fields, or forestlands to differentiate land management units.

Additional Criteria for Contour Guidelines

Hedgerows shall be aligned so they provide permanent contour markers supporting implementation of Contour Farming (330) or Stripcropping (585). Refer to those conservation practice standards for alignment criteria.

Additional Criteria for Screens and Noise Barriers

Screening hedgerows provide privacy, hide unsightly areas from view or reduce noise. Hedgerows shall be located where they most completely obstruct a line of sight or offensive sound. Selected plants shall attain a height and fullness sufficient to break the line of sight or baffle sound.

Additional Criteria for Reducing Particulate Matter Movement

The hedgerow will be oriented as close to perpendicular to the prevailing wind direction as possible. Hedgerow density on the upwind side shall be at least 50% at maturity. Hedgerow density adjacent to the particulate source shall be at least 65% at maturity.

Additional Criteria to Reduce Odor Movement and/or Chemical Drift

Orientation of the hedgerow shall be as close to perpendicular to the prevailing wind direction during the period of concern as possible, and between the source of the odor or chemical drift and the sensitive areas.

Hedgerows shall be located upwind of the odor producing area and the chemical application area.

Tree and shrub species used shall have foliar and structural characteristics that optimize interception, adsorption and absorption of airborne chemicals or odors. Plant species shall be selected that are tolerant of anticipated chemical use.

CONSIDERATIONS

General

Planting a hedgerow larger than the required length and minimum width will increase the amount of carbon stored in the soil and biomass. Larger and more diverse hedgerows will generally enhance most other resource values.

Hedgerows should be planned in combination with other practices to develop holistic conservation systems that enhance landscape aesthetics, reduce soil erosion, improve sediment trapping, improve water quality and provide wildlife habitat.

Hedgerows following land contours create meandering lines on the landscape, produce a natural appearance and increase the availability of “edge” wildlife habitats.

Hedgerows containing a mixture of native shrubs and small trees provide greatest environmental benefits. Use of bareroot and containerized seedlings will accelerate hedgerow development.

Consider the amount of shading a hedgerow will provide at maturity. Shading may impact growth of adjacent plants, microclimate and aesthetics.

Limiting renovation events to one-third of a hedgerow’s length or width will prevent sudden elimination of the practice’s wildlife habitat function.

Consider avoiding the use of plants that spread by root suckers as hedgerow may expand beyond the desired treatment area.

Wildlife Food, Cover and Corridors

Hedgerows can provide travel lanes, or corridors that allow wildlife to move safely across a landscape. Generally, wider corridors accommodate more wildlife use.

Linking fragmented habitats may increase wildlife use of an area.

In grassland ecosystems, hedgerows may adversely affect area-sensitive nesting birds by fragmenting habitat patches and increasing the risk of predation.

Hedgerows can complement the availability of naturally occurring wildlife foods.

Hedgerows can provide wildlife with cover for feeding, loafing, nesting and caring for young.

Dense or thorny shrub thickets provide songbirds with important nesting sites and a refuge to escape predators.

Establishment of evergreen plants provides year-round concealment and thermal cover for wildlife.

Establishment of herbaceous vegetation along the edges of a hedgerow can further enhance the habitat functions of a hedgerow.

Installation of artificial nest boxes with predator guards can encourage cavity-nesting birds and small mammals to utilize a hedgerow.

Living Fences

Thorny shrubs and trees can improve a living fence's barrier effect.

Screens and Noise Barriers

From eye-level, hedgerows reduce the line-of-sight across open areas, concealing objects behind them from view.

Consider the design from viewpoints on both sides of the screen.

Locate noise barriers as close to the source of noise as possible.

Combination of shrubs and/or trees can create more effective screens than single species plantings.

Evergreens provide foliage that can maintain a screen's year-round effectiveness.

Water Quality and Quantity

Water quality benefits may arise from:

- Arresting sediment movement and trapping sediment-attached substances.
- Infiltration and assimilation of plant nutrients.
- Water cooling effects resulting from reducing the incidence of solar radiation on small watercourses through shading.

A hedgerow will increase surface water infiltration by improving soil structure around its root zone. However, evapotranspiration may reduce groundwater recharge benefits.

Incidental Trapping of Snow or Soil

Although not a primary purpose, hedgerows may incidentally trap wind blown snow or soil.

Consider installing hedgerows on alignments that prevent trapping and accumulation of snow and sand on public roads.

Refer to the Windbreak/Shelterbelt Establishment (380) standard for criteria when snow or sand trapping is a primary conservation purpose.

PLANS AND SPECIFICATIONS

Plans and specifications for this practice shall be prepared for each site. Plans and specifications shall be recorded using approved specification sheets, job sheets, or narrative documentation in the conservation plan, or other acceptable documentation.

OPERATION AND MAINTENANCE

Vegetation shall be maintained to ensure continued control of odor movement and chemical drift.

Supplemental planting may be required when survival is too low to produce a continuous hedgerow.

Vegetation shall be protected from unwanted fire and grazing throughout its life span.

Pests shall be monitored and controlled.

Periodic applications of nutrients may be needed to maintain plant vigor.

Renovation activities shall be scheduled to prevent disturbance during the wildlife nesting season.

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USDA United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

MULCHING

CODE 484

(ac)

DEFINITION

Applying plant residues or other suitable materials to the land surface.

PURPOSE

This practice is applied to achieve the following purpose(s):

- Improve the efficiency of moisture management
- Reduce irrigation energy used in farming/ranching practices and field operations
- Improve the efficient use of irrigation water
- Prevent excessive bank erosion from streams, shorelines, or water conveyance channels
- Reduce concentrated flow erosion
- Reduce sheet, rill, and wind erosion
- Improve plant productivity and health
- Maintain or increase organic matter content
- Reduce emisions of particulate matter

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all lands where mulches are needed.

CRITERIA

General Criteria Applicable to All Purposes

The selection of mulching materials will depend primarily on the purpose(s) for the mulch application, site conditions, and material availability. The mulch materials may consist of natural or synthetic materials of sufficient dimension (depth or thickness) and durability to achieve the intended purpose for the required time period.

Prepare the soil surface to achieve the desired purpose.

Apply the mulch material evenly. Use tackifiers, emulsions, pinning, netting, crimping, or other methods of anchoring, if needed, to hold the mulch in place for specified periods.

In cases where furrow erosion may occur due to concentrated flows from mulches(e.g., plastic mulches on beds), take appropriate measures to protect the furrows and the furrow outlets.

Apply manufactured mulches according to the manufacturer's specifications.

Remove synthetic mulches from the field prior to the next crop. Do not incorporate (e.g. disk) synthetic mulches a into the soil.

When mulching with wood products such as wood chips, bark, or shavings or other wood materials, apply a minimum 2-inch thickness of particles that remain in place during heavy rainfall or strong wind events, or both if applicable.

The minimum size of mulching material consisting of gravel or other inorganic mulching is 0.75 inches and applied to a minimum depth of 2 inches.

When mulching with cereal grain straw or grass hay, apply at a rate to achieve a minimum 70 percent ground cover. Determine the mulch rate using the current erosion prediction technology for the intended purpose.

Do not apply plant-based mulch materials with a carbon (C) to nitrogen (N) ratio of less than 20:1 to watercourses.

Additional Criteria to Improve the Efficiency of Moisture Management, to Reduce Irrigation Energy Used in Farming/Ranching Practices, and Field Operations or to Improve the Efficient Use of Irrigation Water

Apply mulch materials to cover at least 90 percent of the soil surface to reduce potential evaporation.

Fine textured mulches (e.g., rice hulls) which allow less oxygen penetration than coarser materials should be no thicker than 2 inches

Additional Criteria to Improve Plant Productivity and Health

When establishing vegetative cover, apply mulch at a rate that achieves a minimum of 70 percent ground cover to provide protection from erosion and runoff and yet allow adequate light and air penetration to the seedbed to ensure proper germination and emergence.

Additional Criteria to Increase Organic Matter Content

Use plant-based mulching materials of suitable quantity and quality to add organic matter, provide food and shelter for soil biota, and protect the soil surface from raindrop impact and crusting, while allowing for adequate soil aeration.

An evaluation of the system using the current approved soil conditioning index (SCI) procedure results in zero or higher.

CONSIDERATIONS

Evaluate the effects of mulching on evaporation, infiltration, and runoff. Mulch material may affect microbial activity in the soil surface, increase infiltration, and decrease runoff, erosion, and evaporation. The temperature of the surface runoff may also be lowered.

Mulch materials with low permeability may adversely affect the water needs of plants.

Avoid excessively thick or tightly packed mulches that can result in soggy anaerobic conditions at the soil surface during wet weather, or prevent rainfall or overhead irrigation from reaching the soil during times of moisture deficit.

Organic materials with C:N ratios of less than 15:1 will release nitrate-nitrogen that could cause water quality impairments. Avoid placing mulch with C:N less than 15:1 to an area of designed flow in watercourses or to an area where the mulch may be transported by surface runoff to a waterway.

Finely divided plant residues (e.g., sawdust) and those rich in soluble carbohydrates (e.g., fresh green-chopped sorghum-sudangrass, corn, or other grasses) that have a C:N ratio greater than 30 can tie up soil N and necessitate supplemental N applications on crops. Coarser materials such as grain straw and chipped brush usually do not reduce crop-available soil N levels unless and until they are incorporated into the soil by tillage or cultivation.

If using municipal greenwaste as mulch, be selective of the source and consider the amount of trash, weed seeds, or non-biodegradable material in the product.

Consider the potential impacts of plastic mulching on the environment and plan for proper disposal methods after its functional use has expired.

Mulching may also provide habitat for beneficial organisms and provide pest suppression.

In attempting to provide habitat for ground beetles,spiders, and other predators of weed seeds and crop pests, use mulch ofsufficient ground cover and suitable thickness and texture for the targetspecies. Avoid excessively thick ortightly packed mulches, which can interfere with the movement of ground beetlesand other beneficial organisms, and may increase the incidence of crop pestsand diseases. Consider mulching cropsonly if the selected mulching materials, and rates of application do not contributeto pest problems.

During the period when weed seed predation is desired and predators are most active, avoid pesticide applications or pesticide exposures that could adversely affect weed seed consumers.

Low permeability mulches (e.g., plastic) may increase concentrated flow and erosion on unmulched areas.

Light-reflecting mulches such as white or aluminized plastic film or bright straw can repel some pests.

Consider potential beneficial or detrimental effects of mulching materials on the biotic community surrounding the crop, including beneficial soil micro- and macro-organisms, as well as plant pathogens and plant pests. These effects are specific to site, mulch, and crop, and may include enhanced soil microbial activity, increased or reduced levels of crop diseases, and toxic (allelopathic) activity against the crop, weeds, or other beneficial or pest organisms.

Keep mulch 3 to 6 inches away from plant stems and crowns to prevent disease and pest problems. Additional weed control may be needed around the plant base area.

Deep mulch provides nesting habitat for ground-burrowing rodents that can chew extensively on tree trunks and tree roots. Light mulch applied after the first cold weather may prevent rodents from nesting.

Some mulch material may adversely affect aquatic environments through changes in water chemistry or as waterborne debris. Consider placing mulch in locations that minimizes these risks.

For all organic or transitioning to organic operations, follow all National Organic Program (NOP) rules.

PLANS AND SPECIFICATIONS

Prepare specifications for each site and purpose on the approved implementation requirements documentation. Documentation must include—

- Purpose of the mulch.
- Type of mulch material used.
- Percent cover or thickness of mulch material, as applicable.
- Timing of application.
- Site preparation.
- Listing of netting, tackifiers, or method of anchoring.
- Operation and maintenance.

OPERATION AND MAINTENANCE

Periodically inspect the mulched areas and reinstall mulch or repair as needed to accomplish the intended purpose.

Evaluate the effectiveness of the mulch (application, amount of cover provided, durability, etc.) and adjust the management or type of mulch to better meet the intended purpose(s).

Remove or incorporate mulch materials will be consistent with the intended purpose and site conditions.

Do not operate equipment near the mulched site that would compromise the intended purpose of the mulch.

Prevent or repair any fire damage to the mulch material.

Properly collect and dispose of synthetic mulch material after intended use.

Monitor and control undesirable weeds in mulched areas.

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Appendix J. Compost Monitoring Log

Below is a compost monitoring log [redacted] can use at the [redacted] For questions about protocols, please refer to the On-Farm Composting Handbook developed by the Northeast Regional Agricultural Engineering Service (1992).

Compost Monitoring Log										
Pile Identification:				Pile Location:			Date Pile Built:			
Feedstocks and Mix Proportions										
Date	Pile Temperature (3 Feet Down)					Air Temp	Moisture Content	Odor	Visual	Notes
	1	2	3	4	5					

Appendix K. Water Testing Best Management Practices

[redacted] staff expressed a desire to determine potential leaching or runoff from the [redacted] into San Pablo Creek. CCRCD Staff discussed this desire and how [redacted] staff may best achieve their goals while also utilizing methods that are easily repeatable, effective, and cheap.

<u>Stormwater Monitoring and Lab Analysis</u>
Given that the [redacted] is, or will be, primarily drip irrigated, stormwater sampling may prove the most effective measure to determine any impact from activities at the [redacted] Runoff potential is very low on the [redacted] given the efficient irrigation system installed and the soil on site. The [redacted] Botella soil base has a saturated hydraulic conductivity (K_{sat}) of 1.43 inches/hour, classifying it in the USGS Hydrologic Soil Group A which is characterized by low runoff potential and high infiltration rates. Saturated hydraulic conductivity measures the ease with which pores of saturated soil transmit water. Given the high rate of 1.43 inches/hour, water moves freely through the soil at the [redacted] resulting in very low runoff into San Pablo Creek.

However, there could still be potential runoff into San Pablo Creek during rain events. CCRCD suggests finding or creating a storm water sampling location on the property, as any data obtained from sampling San Pablo Creek will show stormwater runoff for the entirety of the 42-square mile San Pablo Creek Watershed. Sampling from the ditch along Fred Jackson Way or Brookside Dr. will show results including runoff from the road, but may be the clearest sampling location. CCRCD Staff suggest [redacted] staff further investigate "outfalls" or locations where stormwater is concentrated and collected during storm events. It's important to note that stormwater runoff should only be sampled after a qualifying storm event (QSE) which is defined by the US EPA as a rainfall event with greater than 0.1 inches of rainfall that takes place at least 72 hours from the previous measurable rain event.

For best and most useful results, stormwater monitoring should occur on site at the [redacted] and include at a minimum two samples, one from a pristine source before it enters the farm (rooftop collection, rain barrel collection, etc.) and one before it leaves the farm and enters ditches or San Pablo Creek. In an ideal setting, [redacted] staff would sample the first rain event of the water year, equivalent to a "first flush" that would carry with it any accumulated nutrients, over the course of the previous year. Subsequent analyses during later storms may show impacts, but will be reduced as every storm event carries some nutrient and sediment into San Pablo Creek.

From there, [redacted] can get the water samples tested by professional water quality labs. These labs can further provide quotes for services to [redacted] train [redacted] staff on water quality collecting, and provide additional best management practices that ensure high data quality. This route can be costly with different water quality labs charging different prices for services, but given the relatively small frequency (once or twice per year) may be affordable. [redacted] could also connect with local educational institutions in the surrounding area (Contra Costa College, Diablo Valley College, UC Berkeley, St. Mary's, CSU East Bay, etc.) to determine if chemistry or water quality research professors are seeking water quality monitoring sites along San Pablo Creek.

The Watershed Project

The Watershed Project operates a Water Quality Monitoring Program that tests water quality in streams across Contra Costa County, but especially along San Pablo and Wildcat Creeks. The Watershed Project owns materials and equipment to monitor water quality, and for a nominal fee for chemicals and other single-use testing equipment, may be able to provide the services that [redacted] seeks. For more information, contact Anne Bremer (anne@thewatershedproject.org).

BMI Sampling

A cheap, easy to use, analog for water quality testing is benthic macroinvertebrate sampling. Under this sampling protocol, reaches of creek are assessed for presence or absence of aquatic benthic macroinvertebrates that is then indexed to show approximate water quality. Benthic macroinvertebrate sampling only requires knowledge and identification of benthic macroinvertebrates and should provide a clear picture of any, or no, change along San Pablo Creek upstream and downstream of [redacted] For more information, please visit this website. CCRCD Staff has training in BMI sampling or can connect [redacted] to additional BMI monitors in Contra Costa county.

FAMILY HARVEST FARM CARBON FARM PLAN

March 2023

CONTRA COSTA RESOURCE CONSERVATION DISTRICT

This carbon farm plan was prepared by staff at the Contra Costa Resource Conservation District between November 2022 and March 2023. For more information about this plan or questions, please contact Contra Costa Resource Conservation District.

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This carbon farm plan was developed as part of the Contra Costa County Department of Conservation and Development's "Healthy Lands, Healthy People" grant, funded by the California Department of Conservation's 2020 Sustainable Agricultural Lands Conservation (SALC) Grant Program. Contra Costa Resource Conservation District wishes to thank both the Contra Costa County Department of Conservation and Development and the California Department of Conservation for their funding and support to develop this carbon farm plan.

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Introduction

Carbon is the basis for all agricultural production, and yet has largely been absent from discussions of elements essential for agriculture and the management of working lands. Carbon enters farm systems from the atmosphere through photosynthesis by plants, which uses the energy of sunlight to capture carbon dioxide (CO_2) from the air and combine it with water and nutrients from soil to produce agricultural products: food, fiber, fuel and flora. Furthermore, photosynthates (sugars) produced by plants are moved to the soil directly as exudates from plant roots and from the soil surface through litter from plant parts such as leaves and stems. These feed soil mycorrhizae, thus adding additional carbon to the soil. Another pathway for added soil carbon is through compost and other organic amendments like manure from animals.

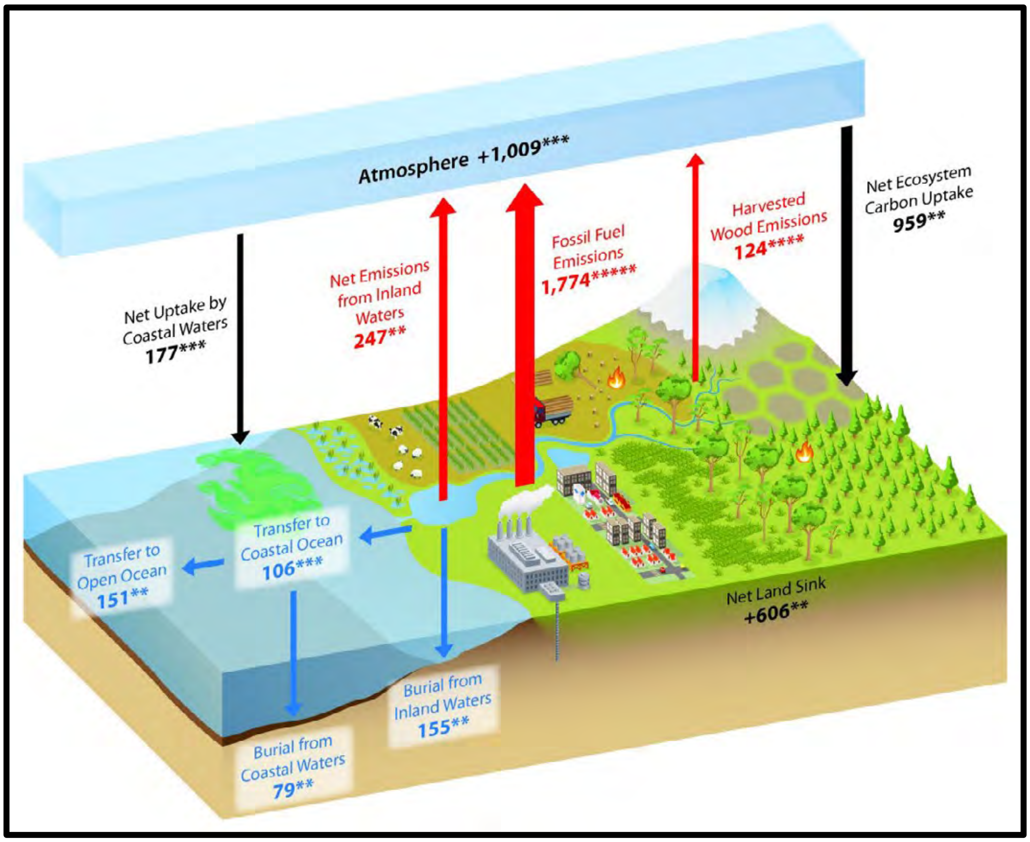

Figure 1. The Carbon Cycle, as modeled by the US Carbon Cycle Science Program.

In addition to its transformation from CO_2 into the sugars, cellulose and lignin of the harvestable crop, carbon can also be beneficially stored long-term (decades to centuries or more) in soils and woody vegetation in a process known as terrestrial carbon sequestration. While the importance of carbon to soil health and fertility has long been understood, its significance in the context of climate change has been increasingly recognized in recent years. Today, land management for increased soil organic matter, which is about 50% carbon, is the core of the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) healthy soils program and the California Department of Food and Agriculture's 2015 Healthy Soils Initiative.

Carbon Farm Planning is the process of identifying opportunities to decrease the production of greenhouse gas on-farm and increase the photosynthetically driven transfer of atmospheric CO_2 to stored carbohydrates in soils and above and below ground biomass. Enhancing working land carbon, whether in plants or soils, results in beneficial changes in a wide array of system attributes including: soil water holding capacity, soil hydrological function, biodiversity, soil fertility, agricultural productivity, as well as resilience to drought and flood. Increasing carbon capture on working lands also helps slow rising levels of CO_2 and other greenhouse gasses in the atmosphere, currently contributing to climate destabilization and unpredictability through global warming.

Carbon Farming

Technically, all farming is "carbon farming," because all agricultural production depends on the photosynthetic process of moving CO_2 out of the atmosphere and into the plant where it is transformed into agricultural products, whether food, flora, fuel or fiber. Atmospheric carbon entering the farm can end up in several locations: the harvested portion of the crop; the standing crop carbon stocks (grassland vegetation, vines and orchards, etc.); the soil as root exudates; the soil organic matter from "waste" materials (compost or manure); or as other permanent woody or herbaceous vegetation (windbreaks, vegetated filter strips, forests and woodlands). While all farming is completely dependent upon carbon, the various farming practices, and the different farm systems, can lead to variable amounts of on-farm carbon capture and storage. The carbon farm planning process differs from other approaches to land use planning by focusing on increasing the capacity of the working farm or ranch to capture carbon and to store it beneficially in the crop, in the standing carbon stocks, and/or in the soil.

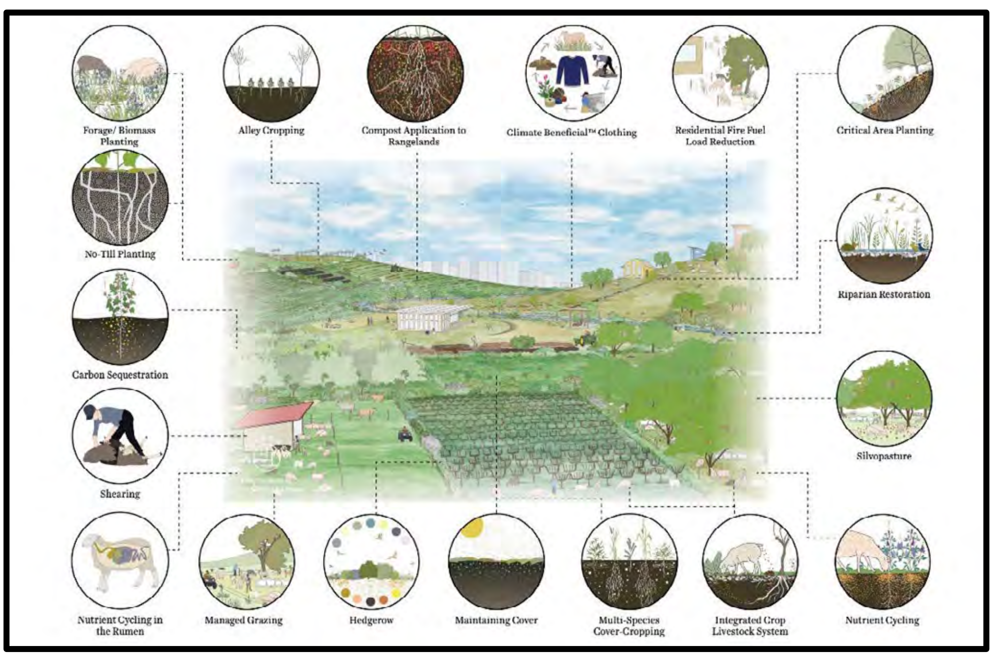

Figure 2. Carbon farming practices, courtesy of Fibershed.

While agricultural practices often lead to a gradual loss of carbon from the farm system, particularly from working land soils, carbon farm planning is successful when it leads to a net increase in farm-system carbon. By increasing the amount of photosynthetically-captured carbon stored, or “sequestered,” in long-term carbon pools on the farm or ranch, carbon farming can result in a direct reduction in the amount of CO_2 in the atmosphere, while supporting crop production and farm resilience to environmental stress, including flood and drought.

On-farm carbon in all its forms (soil organic matter, perennial and annual herbaceous vegetation, plant roots, root exudates and standing woody biomass), contains energy, which originated as the solar energy used by the plant to synthesize carbohydrates from atmospheric CO_2 and water and nutrients from the soil. The carbon in plants and soil organic matter can thus be understood as converted solar energy that enhances on-farm processes. Farming is still viable in low-soil-organic-matter operations, as evidenced by current conventional agriculture, but there are long-term concerns about sustainability and viability of farms as soil organic matter drops. Increased soil organic matter increases soil water-holding capacity and nutrient capture, which further enhances plants and their outputs. With that understanding, carbon farm planning places carbon at the center of the planning process, looking at on-farm resource issues through solutions that also increase carbon sequestration.

The Carbon Farm Planning Process

Carbon farm planning is based upon the USDA NRCS Conservation Planning process. The USDA NRCS Conservation Planning process is a natural resource problem solving and management activity that integrates economic, social, and ecological considerations to meet private and public needs on a farm or ranch (USDA NRCS, 2022). The end goal aims to improve natural resource management, minimize conflict, and address problems and opportunities on-farm. Carbon farm planning utilizes that same framework, but incorporates an additional lens of carbon sequestration as another natural resource issue. This simplifies the planning process and connects on-farm practices directly with ecosystem processes, including climate change mitigation and increases in: on-farm climate resilience, water holding capacity, soil health and agricultural productivity.

Similar to NRCS Conservation Planning, carbon farm planning begins with an overall inventory of natural resource conditions on the farm or ranch, but carbon farm planning focuses on identifying opportunities for reduction of greenhouse gas emissions and enhanced carbon capture and storage by both plants and soils. Building this list of opportunities is a brainstorming process that aims to be as extensive as possible, including everything the farmer and planners can think of to potentially reduce emissions, capture and sequester on the farm, while also balancing food and farm production. While actions proposed in the carbon farm planning should reflect the inherent limits of the farm ecosystem, financial considerations should not limit this initial brainstorming process, as one goal of the carbon farm planning process is to identify potential funding that goesabove and beyond existing resources.. Soil erosion or water quality issues, for example, are addressed in the plans by recognizing the carbon capture opportunities associated with addressing these resource concerns. It is the premise of the carbon farm planning process that these resource concerns arise due to a failure to recognize the central role of carbon in the farm or ranch system, and that by addressing system carbon capture potential, virtually all other resource

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concerns will be addressed.

During this process, a map or maps of the farm are developed to show existing farm infrastructure and natural resource conditions. These maps are used to locate potential carbon capture practices on the farm and to envision how the farm may be expected to look years down the road, following plan implementation.

Next, the carbon benefits of each practice, as potentially applied at the farm scale, are quantified using the online USDA greenhouse gas model, COMET-Farm (cometfarm.nrel.colostate.edu), COMET-Planner, (comet-planner.com), the CDFA Designed COMET-Planner (http://comet-planner-cdfahsp.com/) or similar tools and data sources, in order to estimate metric tons of carbon dioxide equivalent (CO_2e) that would be 1) avoided, or 2) removed from the atmosphere and sequestered on farm by implementing the identified conservation practices. A site-specific list of potential practices and their on-farm and climate mitigation benefits is then developed.

Economic considerations may be used to filter the comprehensive list of practices, and funding mechanisms are identified, including: cap and trade, CEQA mitigation, or other greenhouse gas mitigation offset credits, USDA-NRCS and/or other state and federal programs, and private funds. Practices are implemented as funding, technical assistance and farm scheduling allow. Over time, the carbon farm planning is evaluated, updated, and altered as needed to meet changing farm objectives and implementation opportunities. The fully implemented plan scenario is the ultimate goal or point of reference. Where plan implementation is linked to carbon markets or other ecosystem service markets, periodic Plan evaluation may be tied to those verification or monitoring schedules. Additional information about Carbon Farming is online at: www.marincarbonproject.org and www.carboncycle.org

Family Harvest Farm

In Summer 2021, the Contra Costa County Department of Conservation and Development applied to the Department of Conservation's Sustainable Agricultural Lands Conservation Grant Program in partnership with the University of California, Cooperative Extension and the Contra Costa Resource Conservation District to investigate carbon sequestration potential opportunities within Contra Costa County. Under that grant, Contra Costa Resource Conservation District received funding to write and develop urban farm carbon farm plans. Through discussions internally, staff approached Family Harvest Farm in Fall 2022 and the carbon farm planning process began.

As a participant in the Carbon Farm program, Family Harvest Farm has agreed to an ongoing partnership with the Contra Costa Resource Conservation District through carbon farm assessment, planning and implementation phases. The project will include monitoring and adaptive management to meet landowner and carbon farm planning goals from the implementation phase and beyond.

Map 1. Family Harvest Farm Location Map

Farm Location

Family Harvest Farm is a project of the John Muir Land Trust (JMLT), an agricultural land trust located in Martinez, CA. Family Harvest Farm is a new area for JMLT having previously worked to conserve rangelands and open spaces in the Martinez area near the home of John Muir. In Summer 2020, the farm official broke ground on a 3.5-acre parcel of land in Pittsburg, CA owned by the Pacific Gas & Electric Company. PG&E primarily owns the land as rights of way for power lines. The farm is located at 1300 Power Ave, Pittsburg, CA 94565.

History of Family Harvest Farm

The mission of Family Harvest Farm is "to empower youth and adults to discover and participate in a local food system that encourages healthy living, nurtures the environment, and feeds the community". Further, Family Harvest Farm employs transition-age foster youth in a hand-on job readiness program, teaching marketable skills and preparing them for life outside the foster care system.

JMLT
JOHN MUIR
LAND TRUST

Tribal Recognition and Land Acknowledgement

Family Harvest Farm is currently headquartered in Pittsburg which sits on land historically managed by the Confederated Villages of Lisjan as well as the Bay Miwok Tribes prior to their being driven out and killed by colonizers and missionaries (Native Land Digital, 2022). Family Harvest Farm, and the John Muir Land Trust recognizes this past and is working to restore land access, address cultural erasures, and cultivate opportunities for partnership with local tribal nations and organizations.

While exact historical land management isn't known for this space, we can infer based on the area some historical land management strategies of the Bay Miwok. In general, Bay Miwok land management and residence within riparian adjacent areas included low-intensity burn regimes, vegetation harvesting/tending patterns that prioritized multiple food, medicine, and fiber producing species with minimal soil disturbance prior to the colonial period. Further, the influence of beavers on local water tables through temporary flooding, grazing from native tule elk and blacktail deer, nutrient cycles from salmonids, and other locally-extirpated species likely influenced plant communities and species distribution. (Anderson, 2013)

Prior Agricultural Use

While not fully known, it is likely that the land at one point supported range cattle dating back to some of the first Ranchos in the area, with the first Ranch settling in 1839 after the Mexican government granted 10,000 acres to Jose Antone Mesa and Miguel Jose Garcia (City of Pittsburg, 2023).

Immediately prior to Family Harvest Farm's operation of the property, the site sat vacant for an unknown amount of time, with some annual weed management performed by PG&E or contractors for fuels reduction, and power line tower maintenance. It is speculated that at one point in time, the property may have been used for hay or alfalfa production given larger area trends and uses. In Figure 3 below, the aerial picture on the left from 1939 suggests some sort of large-scale agriculture, likely supplemental feed for livestock.

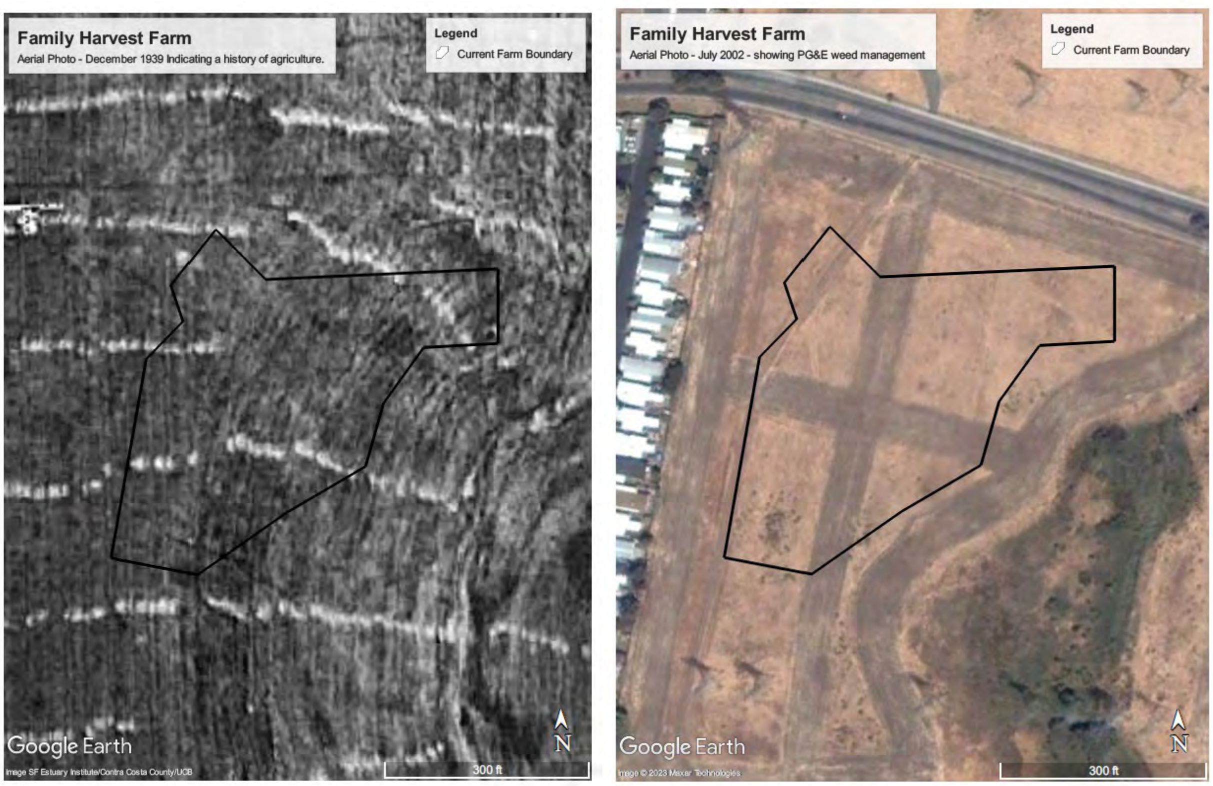
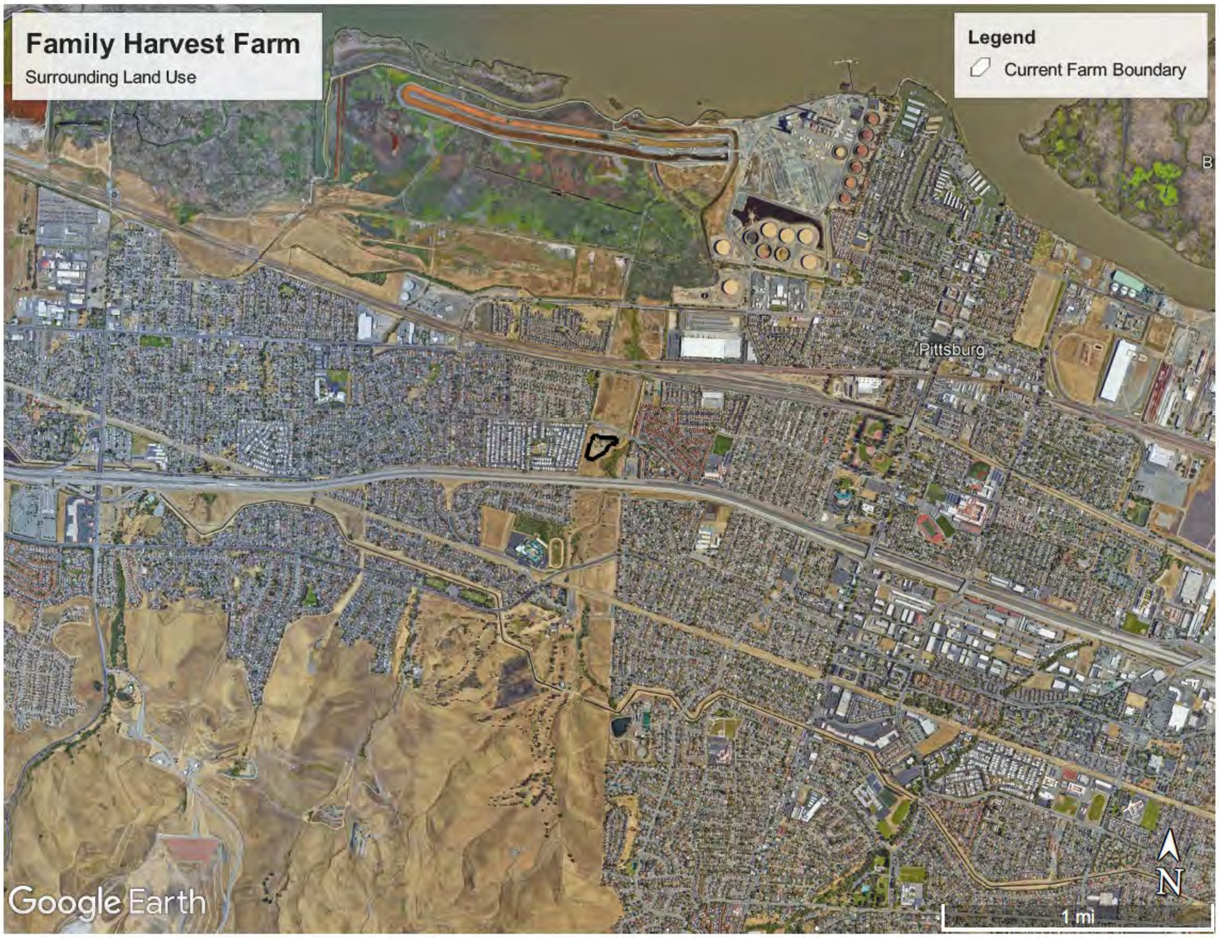


Figure 3. Family Harvest Farm Boundary with 1939 aerial imagery (left) and 2002 aerial imagery (right).

Current Land Use Trends

The Family Harvest Farm property is located on an easement on PG&E right of way for power lines and is surrounded by mixed-use suburban/urban land uses. The property is bordered on the south by State Highway 4 and to the north by Power Ave. To the east and west are suburban housing developments, trailer houses, apartments, and other forms of housing. The site isn't at risk to development as PG&E needs immediate access to the power lines for maintenance. The power lines create substantial easements of little development connecting to the large Concord/Pittsburg Hills open space.



Map 2. Family Harvest Farm surround land use.

Existing Environmental Conditions

Family Harvest Farm is located within Pittsburg, CA - an incorporated city in central Contra Costa County in the East Bay Area of the San Francisco Bay Area, and within the Delta Secondary Zone of the Sacramento River-San Joaquin River Delta as determined by the Delta Conservancy (Delta Stewardship Council, n.d.).

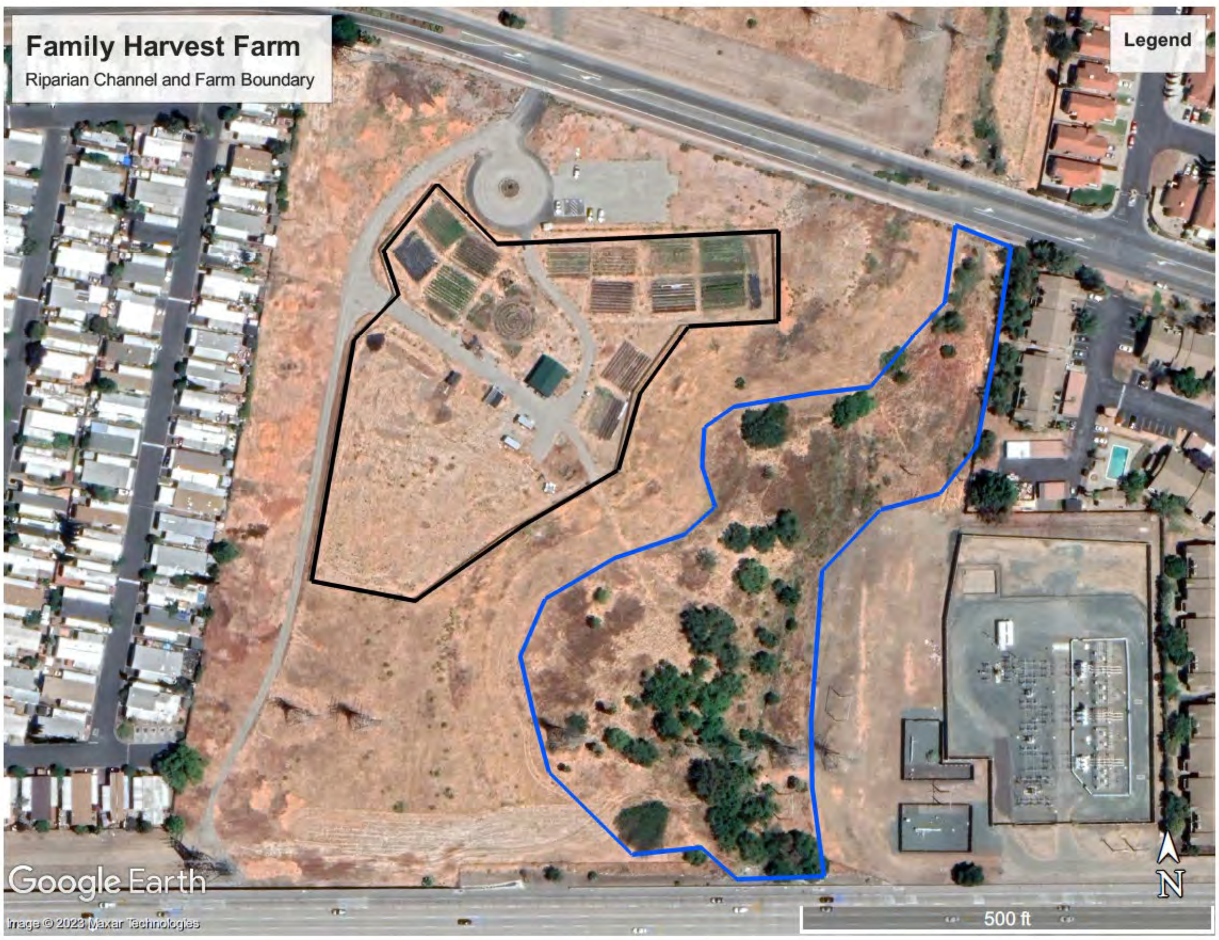
Weather and Climate

Generally speaking, like the rest of California, Pittsburg experiences a Mediterranean climate with hotter and longer summers, and warmer short winters. Pittsburg is located in central to eastern Contra Costa county, behind two rain shadows of the Berkeley/Oakland Hills and the Concord/Pittsburg hills, which leads to lower rainfall and dryer conditions as compared to other parts of Contra Costa county. Historically, precipitation averaged around 12-14 inches per year, but is likely decreasing as a result of changing climate and increased drought conditions (WeatherSpark.com, n.d.). Temperatures fluctuate throughout the year, but typically are around 40 degrees in the Winter and up to 90 degrees in the summer.

Photo 1. Photo from Family Harvest Farm fence line looking down at Riparian Area, taken December 2022.

Sensitive Environmental Areas

Family Harvest Farm is located next to an unnamed riparian channel and seasonal creek that drains to a wetland complex and the Sacramento River-San Joaquin River Delta approximately 1-mile downstream. The farm itself is set back from the creek but close enough that Family Harvest Farm visitors and employees would relax in the shade during meals or breaks. In Summer 2022, PG&E, fearing homeless encampments in the riparian area and potential fire hazards, elected to remove all vegetation from the riparian channel and cut down a number of riparian trees and shrubs. When carbon farm planners visited in December 2022, riparian vegetation was beginning to emerge from root systems of remaining vegetation (Willows, Cottonwoods, etc.).There are invasive weeds present on other stretches of the riparian area, but no invasive species were observed near sections adjacent to Family Harvest Farm.

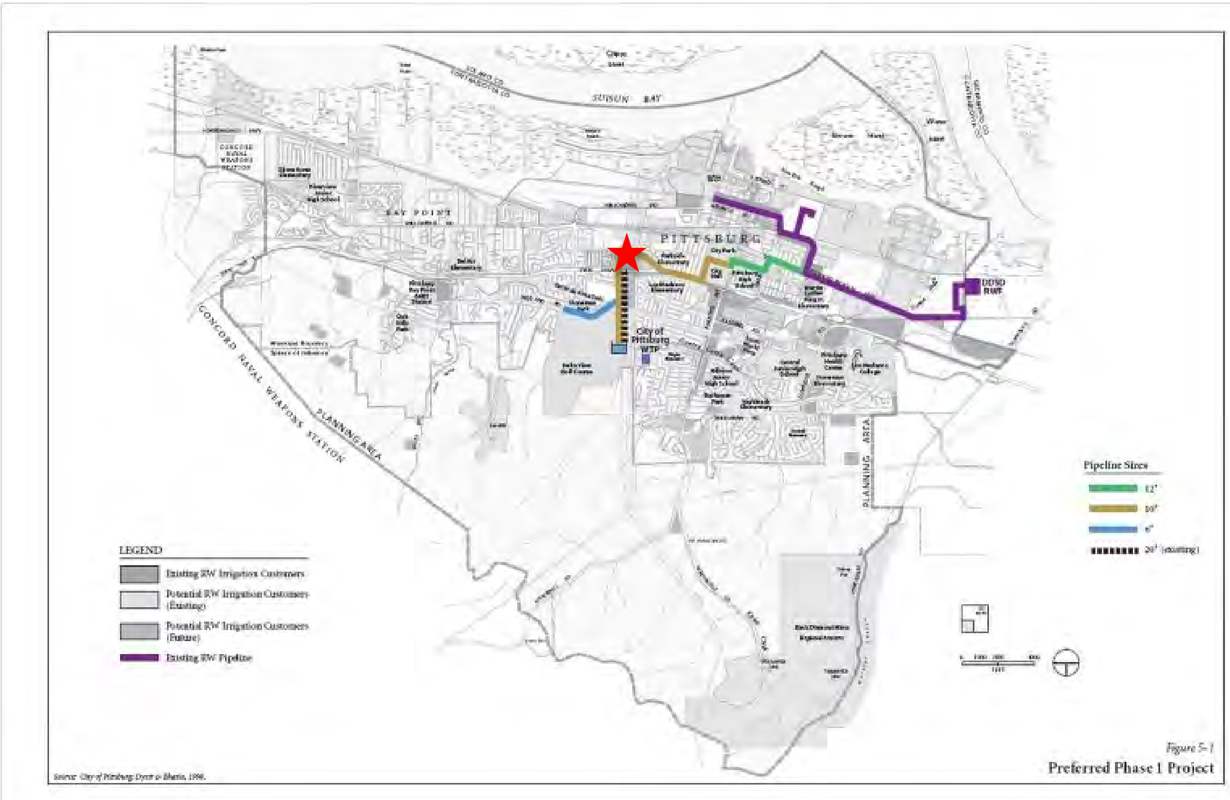


Map 3. Family Harvest Farm and adjacent riparian corridor.

Water

Family Harvest Farm is irrigated and has an existing water meter that irrigates the various vegetable beds across the farm. Drip irrigation is the main tool utilized to water the beds on the farm, and water is provided by the City of Pittsburg and the Contra Costa Water District at municipal water prices.

The City of Pittsburg currently utilizes recycled water or “purple pipe” to maintain landscaping projects with water from the Delta Diablo Sanitation District (City of Pittsburg, n.d.). As currently constructed, there is an existing recycled water line on farm that runs adjacent to the apartment complex. Originally, the farm chose alternative water sources concerned with the high salt content of the recycled water and potential impacts to soil. Further investigation is warranted regarding water quality and impacts to agriculture as this could be a significant way to reduce costs on-farm.



Map 4. City of Pittsburg and existing "Purple Pipe." Map provided by the City of Pittsburg with Family Harvest Farm location (red star) added by CCRCD Staff.

Soil

The USDA Natural Resources Conservation Service (NRCS) surveyed the soils of Contra Costa County in 1977 and then again in 1987 (USDA NRCS, 2022). It is assumed that given the lack of substantial development (buildings, etc.) and that without testing that the soil surveys are still representative and haven’t substantially changed since 1987. The soil survey found two significant soil types within the Family Harvest Farm.

Table 1. Soils across entire Family Harvest Farm Parcel

Map Unit Symbol	Map Unit Name	Acres within Area of Interest	Percent of Area of Interest
RbC	Rincon clay loam, 2 to 9 percent slopes, MLRA 14	10.4	64.9%
CaA	Capay clay, 0 to 3 percent slopes, MLRA 17	5.4	33.9%
Totals for Area of Interest		**15.8**	**98.8%**

Table 2, Soils from Family Harvest Farm with updated acres and percentages within fenced planting area

Map Unit Symbol	Map Unit Name	Acres within Area of Interest	Percent of Area of Interest
RbC	Rincon clay loam, 2 to 9 percent slopes, MLRA 14	3.0	84.4%
CaA	Capay clay, 0 to 3 percent slopes, MLRA 17	0.6	15.6%
Totals for Area of Interest		**3.6**	**100%**

Map 5. Soils Map for Family Harvest Farm from NRCS Web Soil Survey. Report is included in Appendix.

RbC – Rincon clay loam, 2 to 9 percent slopes

The Rincon clay loam component is the dominant soil type at the Family Harvest Farm, accounting for the majority of the current farmed acreage. The Rincom series consists of deep, well- drained soils formed from alluvial material from sedimentary rocks in the upper watershed. These sedimentary rocks are found typically in valley bottoms and alluvial fans which is consistent given the proximity of both Family Harvest Farm and the unnamed creek that passes through the area.

This soil typically has a shallow organic matter content of 1.5% from 0 to 46 inches, then dropping to 1% from 46-132 inches. If irrigated, this soil is also considered prime farmland. This soil is rated Grade 1 – excellent by the California Revised Storie Index. A majority of the beds on the Family Harvest Farm are planted within this soil.

CaA – Capay clay, 0 to 3 percent slopes

The Capay clay series is another large soil type within the area that only partially covers the Family Harvest Farm, mainly in the part of the property that is classified as riparian habitat. These soils are not as well-draining as the Rincon series mentioned previously, but are still classified as prime farmland if irrigated. This soil series is typically found on flood basins, alluvial fans, and basin rims.

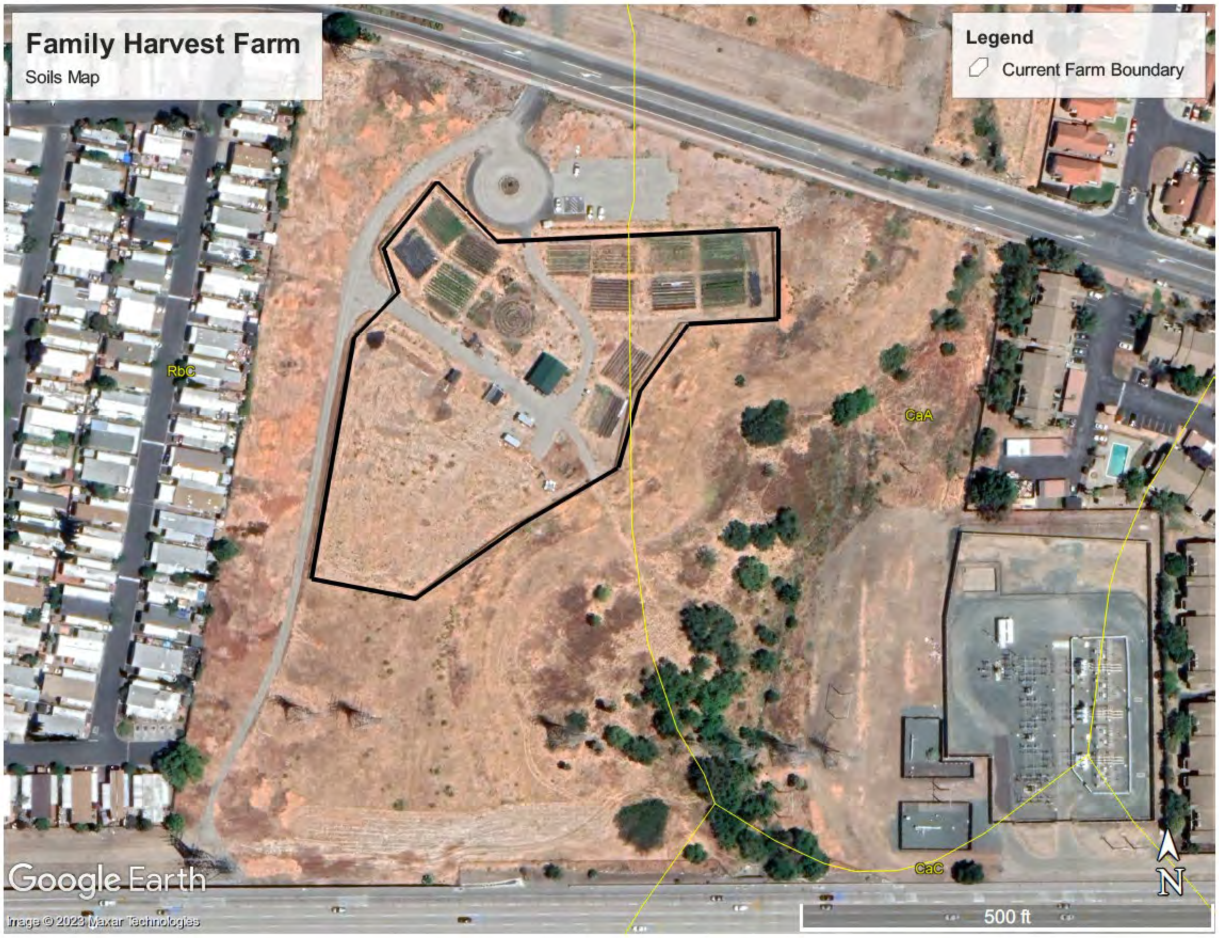
This soil also has a more shallow organic matter content, observed at 1.9% for the first 15 cm before dropping below 1% at 69 cm and below 0.5% at 90 cm. While it has a lower soil organic matter content and is rated Grade 3 by the California Revised Storie Index, it is still suitable for agriculture and is commonly found on the western edge of the Sacramento Valley and the intermountain valleys of the Coast Range of Northern California.

Family Harvest Farm Soil Testing

Initial soil tests conducted prior to ongoing agriculture of the property concluded that the soil organic matter content was between 2 and 3%. Family Harvest Farm sent in several soil samples after farming to UMASS Extension Soil and Plant Nutrient Testing Laboratory in June of 2021. The conclusions are included below along with recommendations for particular crops and beds. The full report is included within the appendix.

Notes, conclusions, and recommendations:

- Soil organic matter (SOM) measured an average of 5.4% between seven different sampling sites in active beds, a reflection of the farm manager’s consistent application and use of compost, woodchips, and other soil building practices.
- Soil test values for Phosphorus (P), Potassium (K), Calcium (Ca), and Magnesium(Mg) were all noted to be excessive in overarching tests
- Applying Nitrogen was recommended between early Spring and mid-June
- Overall recommendations focused on avoiding over-fertilization



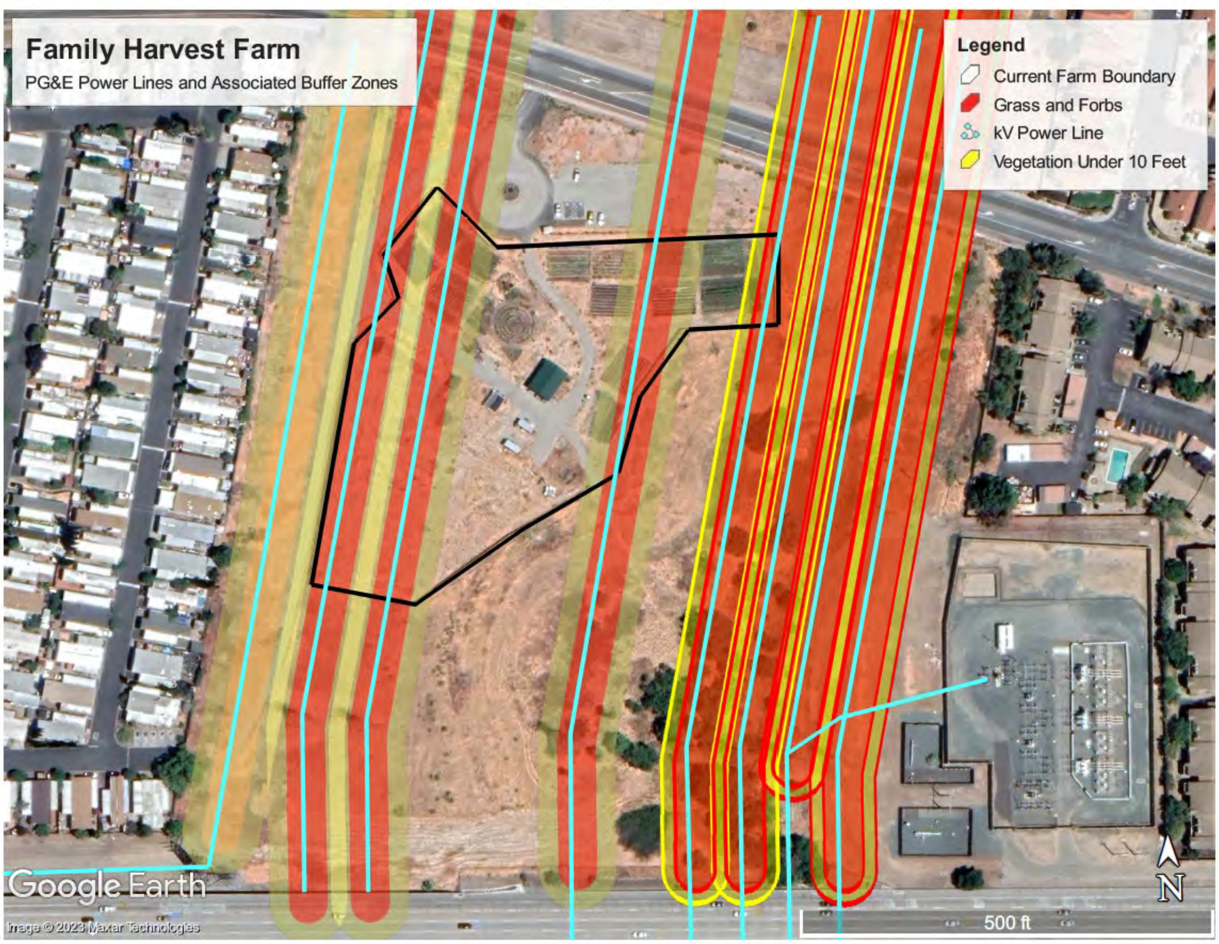
Map 6. Family Harvest Farm with available soils data, courtesy California Soils Web. (California Soil Resource Lab, 2022)

Vegetation Height Restrictions

Family Harvest Farm is sited on a PG&E transmission tower easement in Pittsburg, CA. Prior to management by Family Harvest Farm, PG&E managed the site for weed abatement through spraying and mowing of annual weeds. PG&E remains concerned about vegetation on site, and the potential for taller vegetation, primarily trees, to interfere with power lines and potentially spark and start a fire. In conversations with PG&E, Family Harvest Farm reported vegetation height restrictions on the property depending on proximity to the various transmission lines. Map 7 below shows various zones on the property and vegetation height limits, and is detailed further in Table 3.

Table 3. Vegetation Restrictions by PG&E defined Wire Zones

Zone Name	Definition	Vegetation Height Restriction
Wire Zone	Area underneath transmission lines, 15 feet on center point transmission tower.	Grasses and forbs, or vegetable row-crop plants
Wire Zone Buffer	Four western most wires (Map 7) are 230 kV wires and have a 15ft buffer on either side. Eastern wires (pictured over the riparian area) are 115 kV wires and have a 10ft buffer on either side.	Vegetation height restriction of 10 feet.
Outer Zone	Area outside of buffer zones.	Taller trees will be pruned by PG&E to avoid transmission lines



Map 7. PG&E Power Lines and associated vegetation restricted areas at Family Harvest Farm.

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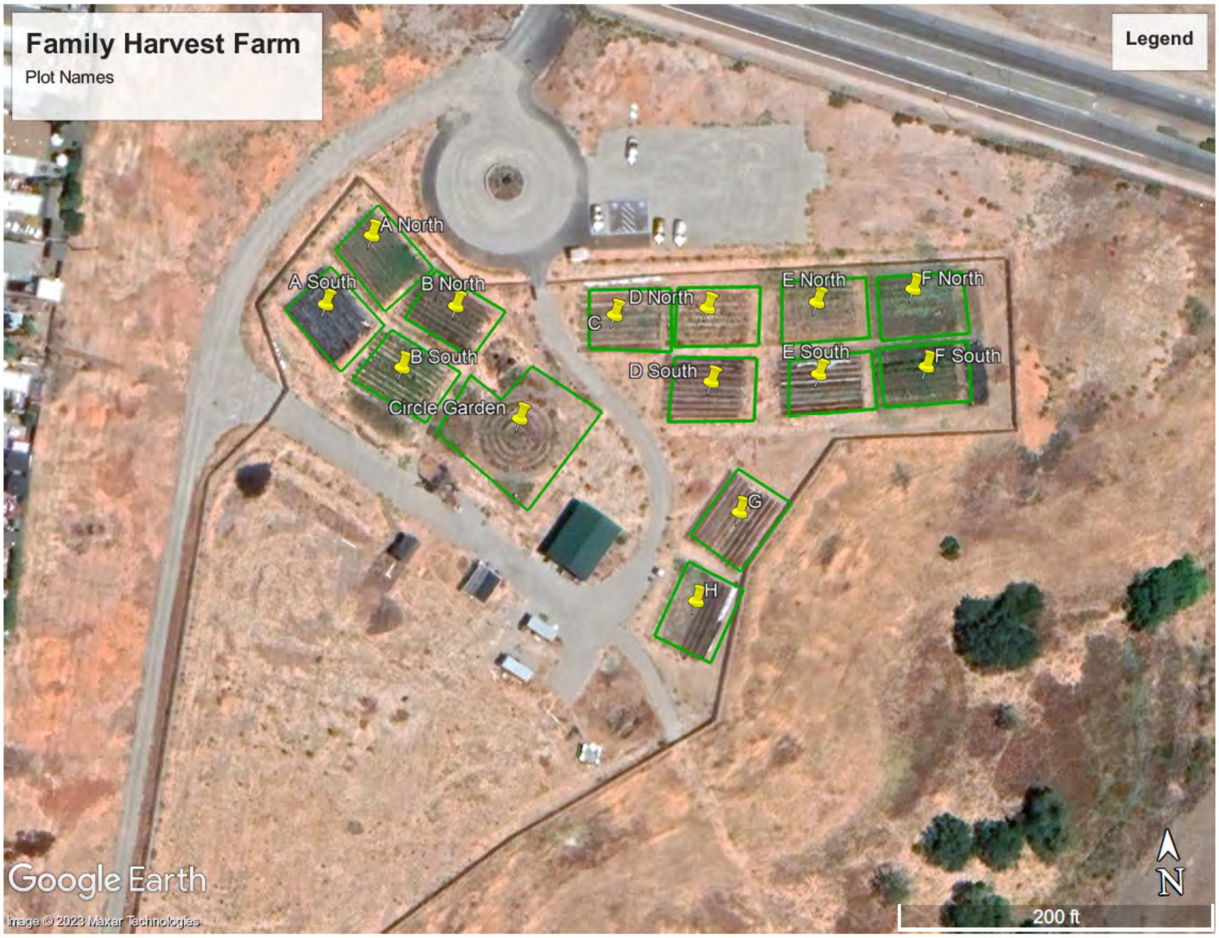
Cultivated Vegetation

Planners observed 14 planting areas during the November site visit that are actively managed and cultivated. Most of these planting areas (13 of 14) are rectangular plots ranging anywhere from 180-200 square meters or 0.05 acres. The last planting area is a circular herb garden with rings of garden herbs totaling nearly 0.1 acres. These plots total approximately 0.72-acres of total cultivated acreage across Family Harvest Farm as of Spring 2023. While site visiting, the farm manager Mary Cherry expressed an interest in expanding the size of the cultivated area through orchard or other row-crop system plantings on the un-cultivated southern portion of the fenced area.

Table 4. Family Harvest Farm plots and acreage as calculated in Google Earth.

Plot Name	Mapped Plot Area*	Plot Name	Mapped Plot Area*
A North	193 square meters	E North	197 square meters
A South	192 square Meters	E South	181 square meters
B North	169 Square Meters	F North	203 square meters
B South	192 Square meters	F South	196 square meters
C	185 square meters	G	195 square meters
D North	183 Square meters	H	187 square meters
D South	199 square meters	Circle Garden	471 square meters
		TOTAL	**2943 square meters**

*Calculated using Google Earth Projections and not verified in the field.



Map 8. Family Harvest Farm plots as of March 2023.

Vegetation

Prior to John Muir Land Trust management in 2018, PG&E conducted annual mowing and pesticide applications to keep vegetation and fire risk at a minimum along the flat land south of Power Avenue and north of Highway 4. This resulted in the prevalence of unvegetated areas with exposed soil, Mediterranean annual grass species, tumbleweeds, and other invasive vegetation. Since farm establishment, annual and perennial crops, fruit trees, herbs, and flowers have been planted within the farm fence.

From 2021-2022, native plant hedgerows were established on-farm that included: manzanita, Artemisia, Cleveland sage, milkweed, Coyote brush, and others. Within the riparian corridor, native Arroyo Willows, California black walnut, as well as introduced Camphor and Fan palms were growing as overstory to mixed wet-meadow species of both annual and perennial grasses, forbs, and native Narrowleaf Milkweed. In the fall of 2022, these existing native riparian woodland species were clear-cut by PG&E, with native willows now re-sprouting from the base. Invasive species management includes Arundo and Himalayan Blackberry, Camphor, and exotic annual grasses and forbs.

Resource Issues, Goals and Objectives

Farmer Goals and Objectives

Through multiple discussions with the farm manager, it has been shared that the goals for the farm, and those stewarding it, lay at the intersection of ecological, social, and economic success and health. The following notes represent the main priorities of Family Harvest Farm in the upcoming seasons, centered around evolving from surviving to thriving:

Ecological:
- Restored and engaged stewardship of the riparian channel
- Establishment of on-site composting and accompanied soil fertility building practices
- Additional hedgerow and windbreak planting
- Perennial food crops and orchard establishment

Social:
- Further cultivate and expand the farm as a demonstration site for a range of traditional-regenerative practices for general public, farmers, community members
- Create additional space for education and youth leadership/learning
- Add diversified trainings and Service Learning opportunities
- Host and participate in tours of neighboring agricultural operations
- Build additional community support and engagement
- Increase the number of apprentices and land stewards

Economic:
- Work with partners to secure funding pathways that support ecological and social goals
- Hire additional farm management support
- Identify and pursue trainings to support the farm manager(s)
- Establish a greenhouse to limit reliance on off-site plant starts and seeds, and create additional opportunity for business/farm management learning

Known Resource Issues:

The resource concerns identified for Family Harvest Farm have been itemized during multiple site visits and informal discussions over the course of 2020-2022 and can be organized into general categories of soil health, water conservation, biodiversity, and human and environmental health. All of these also inform carbon sequestration practices.

Soil Health and Quality
- Lower organic matter content when the farm started in 2019/2020, improved over time through soil building practices (cover crops, mulch, compost, etc.)
- Less productive areas and plots on farm because of differences in soil composition
- Likely historical herbicide use across this parcel for weed management, potentially still ongoing on unfarmed parts of parcel

Water Quantity, Quality and Conservation

- Water costs are high as the farm is being charged municipal rates rather than agricultural rates
- Hydrology and flood pulse of the riparian zone
- Trash flowing in creeks during and after storms, littering riparian corridor

Stewardship of Adjacent Areas

- Riparian corridor restoration and management to reduce fire risk, preserve riparian corridor
- Bird/bat/raptor conservation adjacent to power lines
- Ground squirrel management
- Long-term vegetation management of unfarmed areas

Human and Environmental Health

- Wind tunnel coming from the West and both wind and sound coming from Highway 4 to the south border of the farm and riparian zone
- Air pollution from freeway
- Trash and toxic substances from storm drains

Photo 2. Future hedgerow/pollinator patch east of F Plot at Family Harvest Farm, taken December 2022.

Climate Smart Practices

Existing Climate Smart Practices

Family Harvest Farm currently practices a number of climate-smart agricultural practices with the goal of improving soil quality, improving air quality, and decreasing the potential negative impacts of their farming. Below is a brief sampling of observed and discussed practices from the November 29th, 2022 and December site visits.

Cover Cropping

Family Harvest Farm reported using cover crops to build soil within each of the beds and keep the soil covered. The common cover crop is fava beans for their ability to fix Nitrogen (N). The farm manager also implements a mix of mix of Spring Forage Pea, Common Vetch, Dixie Crimson Clover, Goliath Spring Oats, Lavina Beardless Spring Forage Barley, Trophy Rapeseed, Golden Flax, Black Oil Sunflower, Nitro Radish, and Florida Broadleaf Mustard from Green Cover Seeds. The cover cropping is happening at a staggered rate as the farm attempts to keep something producing in the ground regularly to provide year-round food support for their community. The cover crop is then laid down and tarped to help build SOM.

Mulching

Family Harvest Farm currently utilizes cover crop mulching practices on all active beds on the property. This practice entails leaving a terminated cover crop on the beds and covering them with tarps. This is a newer practice being implemented by the farm manager in an effort to suppress weeds, build soil health, retain water, and promote plant health. As mentioned previously, this mulching occurs at a staggered rate across the farm to accommodate food support year-round for their community. Mulching is also provided by tree companies looking to offload wood chips. These are mostly used along walking paths, but occasionally within the planting beds as well.

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Photo 3. Farm dogs helping spread mulch at Family Harvest Farm, taken in March 2023.

Compost

During the site visit, Family Harvest Farm, the farm manager shared their practice of compost application to active and inactive beds using both horse manure from a local barn and a large compost pile on site. The compost application process includes vermicompost; Family Harvest Farm is assisted by a local vermicompost company called Delta Worms. Family Harvest has not tested their compost to determine actual compost chemical content.

CCRCD staff also inquired about application rates, and the farm manager shared that they have applied 45-50 cubic yards of compost annually to all cultivated acreage, equaling 25,025 square feet or 0.57 acres. Depending on water content, that can vary anywhere from 800-1500 lbs per cubic yard, or 0.4-0.75 tonnes per cubic yard, for an estimated 18–38 tonnes of compost applied across the farm. Spread across the cultivated acreage, that works out to an estimated application rate of 25-50 tonnes/acre, which exceeds the CDFA Healthy Soils Program recommendation of 2-8 tons/acre depending on crop type.

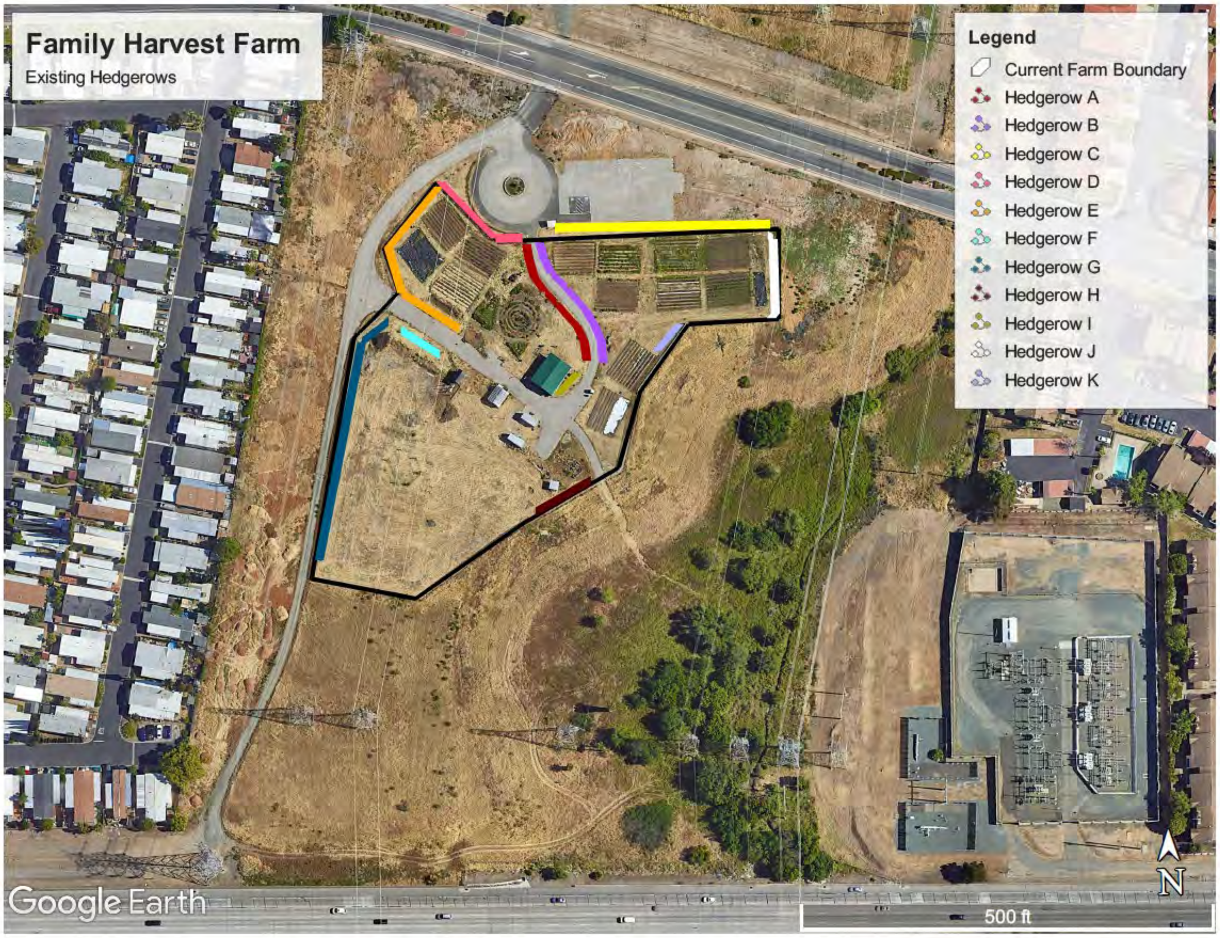
Hedgerows

Over the past year, Family Harvest Farm has planted several borders of the farm property with native hedgerows to attract pollinators and provide shelter and windbreaks from the surrounding roadways. One bed on the north east corner of the property was also planted with native grasses, forbs, and shrubs as a part of a Xerces habitat kit, NCAT funding, and CDFA Healthy Soils Program funding. Family Harvest Farm is currently working on planting orchards in the back of the property, and CCRCD recommends additional hedgerows be planted along that southern property line. Map 9 details currently planted hedgerows and the associated names.

Table 5. Existing hedgerow names and lengths at Family Harvest Farm.

Hedgerow Name	Hedgerow Length	Hedgerow Description
A	164 ft	Entrance Hedgerow - West of Path
B	169 ft	Entrance Hedgerow - East of Path
C	261 ft	Parking Lot Hedgerow - South of Parking Lot
D	128 ft	Roundabout Hedgerow - South of Roundabout
E	234 ft	West and South of Plot A
F	56 ft	West of Chicken Coop
G	309 ft	West of Future Orchard
H	77 ft	West of Riparian Entrance
I	35 ft	West of Educational Barn
J	105 ft	East of Plot F
K	43 ft	Northeast of Plot G
TOTAL	**1581 ft**	**Total linear hedgerow footage**

Photo 4. Hedgerow A at entrance to Family Harvest Farm, taken December 2022.



Map 9. Family Harvest Farm existing hedgerows

<u>Reduced Tillage</u>

Family Harvest Farm reported that they are trying to disturb the soil as little as possible. For each of the active beds, one pass has been made by a compact tractor with a tilling implement attached to prep the compacted soils for planting. Following this initial pass, the farm manager has implemented a number of practices to build soil health, including (but not limited to) compost application, cover crop, cover crop mulching. Broad forks have also been utilized by the farm manager and farm volunteers. The initial compaction of the soil made it nearly impossible for crops to establish a root zone initially; the farm manager is hoping that implementing the aforementioned practices will enable them to move forward without disturbing the soil with tillage.

Table 6. Family Harvest Farm Current Climate-Smart Ag Practices

Climate-Smart Agricultural Management Practice and NRCS Conservation Practice Number	CO_2e Sequestered Annually (tonnes CO_2 equivalent/year)	Co-Benefits
Cover Crop – CPS 340	.24	Improved soil organic matter, soil fertility, increased soil moisture holding capacity, increased drainage, weed suppression
Hedgerow (CPS 422)	2.44	Provide habitat for wildlife, improve microclimate, stabilize soils, improve water quality and habitat diversity, reduce water loss
Compost Application to Row Crops (CPS 808)	2.76	Increase soil organic carbon, Improved soil water and nutrient holding capacity;
Reduced Tillage (CPS 329)	.13	Reduced labor cost, reduced soil organic carbon loss, improved mycorrhizal health and function
Mulching (CPS 484)	.13	Improved soil organic matter, soil fertility, increased soil moisture holding capacity, increased drainage, weed suppression
TOTAL	**5.70**	

Climate Smart Practice Recommendations

CCRCD developed the following recommendations after site visits and correspondence with the Family Harvest Farm manager. The recommendations take into consideration current practices being implemented as well as longer-term farm goals, which includes the expansion of cultivated acreage under power lines following PG&E height restriction . With these restrictions in mind, the farm manager and CCRCD staff determined that there is a 1-acre area that could suitably grow row vegetable crops in beds (similar to other parts of the farm), and a .37 acre area between the power lines that remains free of vegetation height restrictions (provided the trees are pruned so as not to interfere with the powerlines). CCRCD assumes that the orange polygon will be a row-crop vegetable system similar to current operations, while the purple polygon could feasibly support a low-height U-pick variety dwarf orchard to provide additional fruit and nut products.

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Map 10. Recommended Climate Smart Management Practices at Family Harvest Farm

Cover Crop

CCRCD recommends that Family Harvest Farm continue to use cover crops as needed to achieve management goals of the farm. Recognizing that the non-production season is short, Family Harvest Farm may consider retiring beds for a season to implement a cover crop over the course of a couple weeks or month to sequester carbon dioxide, increase nitrogen, or support other management goals, and provide rest to the soil between plantings. As Family Harvest Farm continues experimenting with cover crop mulching, recommendations may shift depending on practice results; namely, if the cover crop mulching succeeds in managing weed incursion.

While orchards are not planted yet, when plantings start in Spring 2023, CCRCD recommends a concerted weed removal effort to cut down on invasive weeds and allow the orchard to fully absorb nutrients, water, and other needed plant growth elements to grow and produce more fruit. As part of this process, CCRCD recommends developing an integrated pest management plan for the orchard to first identify and assess the weeds on site, develop action plans and timelines, and then work to keep the orchard weed free. While string trimming or hand pulling weeds is one possible option, CCRCD recommends exploring a potential “chicken lawn mower,” a small chicken coop that can be moved through the orchard to allow the chickens to eat the weeds while they’re small and fertilize the soil underneath. Chickens are currently on site at the farm, but are in a stationary coop.

When the weeds have been cleared, CCRCD recommends continuing to try to implement a perennial cover crop in the orchard. The farm manager has implemented a mix of Spring Forage Pea, Common Vetch, Dixie Crimson Clover, Goliath Spring Oats, Lavina Beardless Spring Forage Barley, Trophy Rapeseed, Golden Flax, Black Oil Sunflower, Nitro Radish, Florida Broadleaf Mustard and favas in the past, and CCRCD will assist in determining if this mix is appropriate for the management practice goals of the orchard when the time comes.

Additional Resources and Reading Material:
UC SAREP Cover Crop Seed Database
USDA Native California Cover Crop and Seed Vendors Resource
UCCE: Orchard Cover Crops

Compost Application

The CCRCD recommends that Family Harvest Farm continues making compost on site. As time goes on and with improved soil building techniques, compost application may not be as crucial once a target soil organic matter is achieved. Still, soil building is a slow process so for the time being it is highly recommended that both the planned orchard and the current row crops receive healthy applications of compost.

While the current compost is made of horse manure, pulp, and straw (a high carbon, low nitrogen compost), as well as the addition of vermicompost, CCRCD recommends continuing to monitor and assess soil conditions to determine if a higher nitrogen compost is needed to achieve soil health goals.

In general, higher carbon compost (C:N >11) provides more available carbon for microorganisms to lock up into deeper sequestration, promoting better soil health. Higher nitrogen composts can more easily lose nitrogen to the atmosphere in the form of methane or nitrous oxides and are characterized by bad odors, or potentially spontaneous combustion at the wrong ratio. The most current soil tests completed on farm also included notes with recommendations of nitrogen application. With regards to cropland use, the needs of different fields will require different compost types as time goes on. Soil monitoring should inform needs in order to better manage on-farm created compost.

CCRCD also recommends that Family Harvest Farm send in samples of current on-farm compost to better understand chemical content and additional soil health needs. Soil testing by Family Harvest Farm has provided a number of recommendations for various nutrients and to avoid adding excessive nutrients if not needed.

CCRCD recommends a robust monitoring protocol be adopted by Family Harvest Farm for both purchased off-site compost and on-site compost creation to determine true compost application rates, materials, and results of compost creation. Robust monitoring should equip Family Harvest Farm with a better understanding of the inputs into the farm.

Finally, CCRCD recommends further investigation and discussion into compost application rates to ensure that Family Harvest Farm is not over-applying compost on fields. At present, CCRCD Staff estimate that Family Harvest Farm is applying 45-50 cubic yards of compost annually, or approximately 25+ tons of compost/acre. Under the CDFA Healthy Soils Program, CDFA will only pay, and recommends application rates ranging from 2-8 tons/acre depending on management goals. While 25+ tons of compost/acre may be providing benefits, CCRCD Staff expect that over time, less compost will need to be applied as soil healthy goals are

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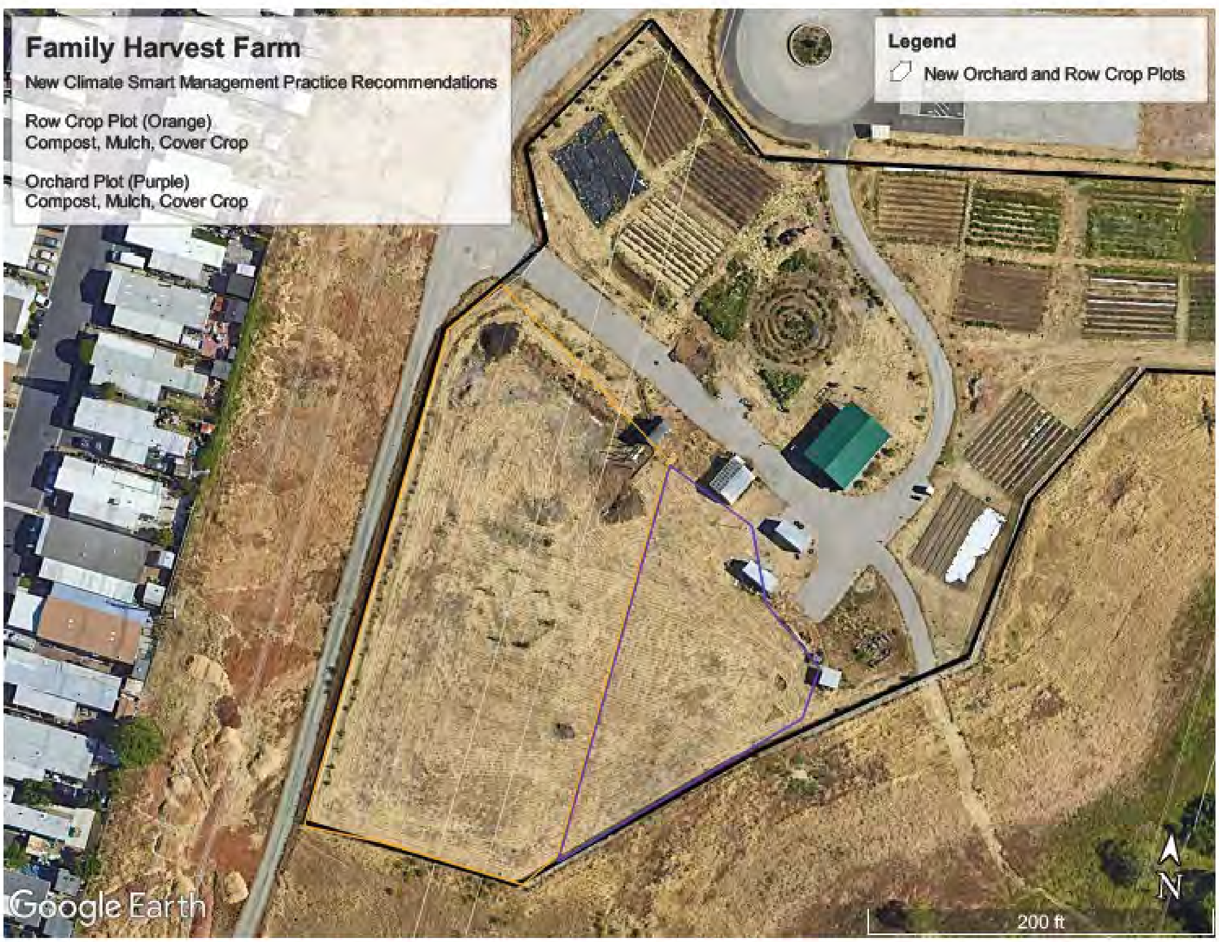
met.

Additional Resources and Reading Material:
CDFA On-Farm Compost Resources
CDFA Compost White Paper

Mulching

CCRCD recommends Family Harvest Farm continue to mulch the row crops as a means to retain water in the soil and long-term provide carbon and improve soil health. In the planned orchard especially, CCRCD recommends vigorous mulching as a potential strategy to reduce invasive weed pressures. Wood chips, at approximately 3-4 inches thick, can be an effective barrier to keep weeds manageable, prevent growth, and trap water for use by the orchard.

Additional Resources and Reading Material:
UCANR Mulches for Landscapes Publication



Map 11. Proposed new row crop plot and orchard plot at Family Harvest Farm

Hedgerows

CCRCD recommends Family Harvest Farm continue to manage planted hedgerows and install more hedgerows on the boundaries of the farm and where possible along paths, driveways, and field edges. CCRCD will continue to work with Family Harvest Farm on where in particular to establish hedgerows and windbreaks in accordance with PG&E guidelines, as there are multiple power lines crossing the farm that necessitate a height-limitation with some plantings. Windbreaks in particular will prove to be particularly useful as the farm lies between two major roadways and is subject to high winds as well as vehicle noise. For more information on hedgerow and other planting height limitations, please refer to Table 3 on page 20.

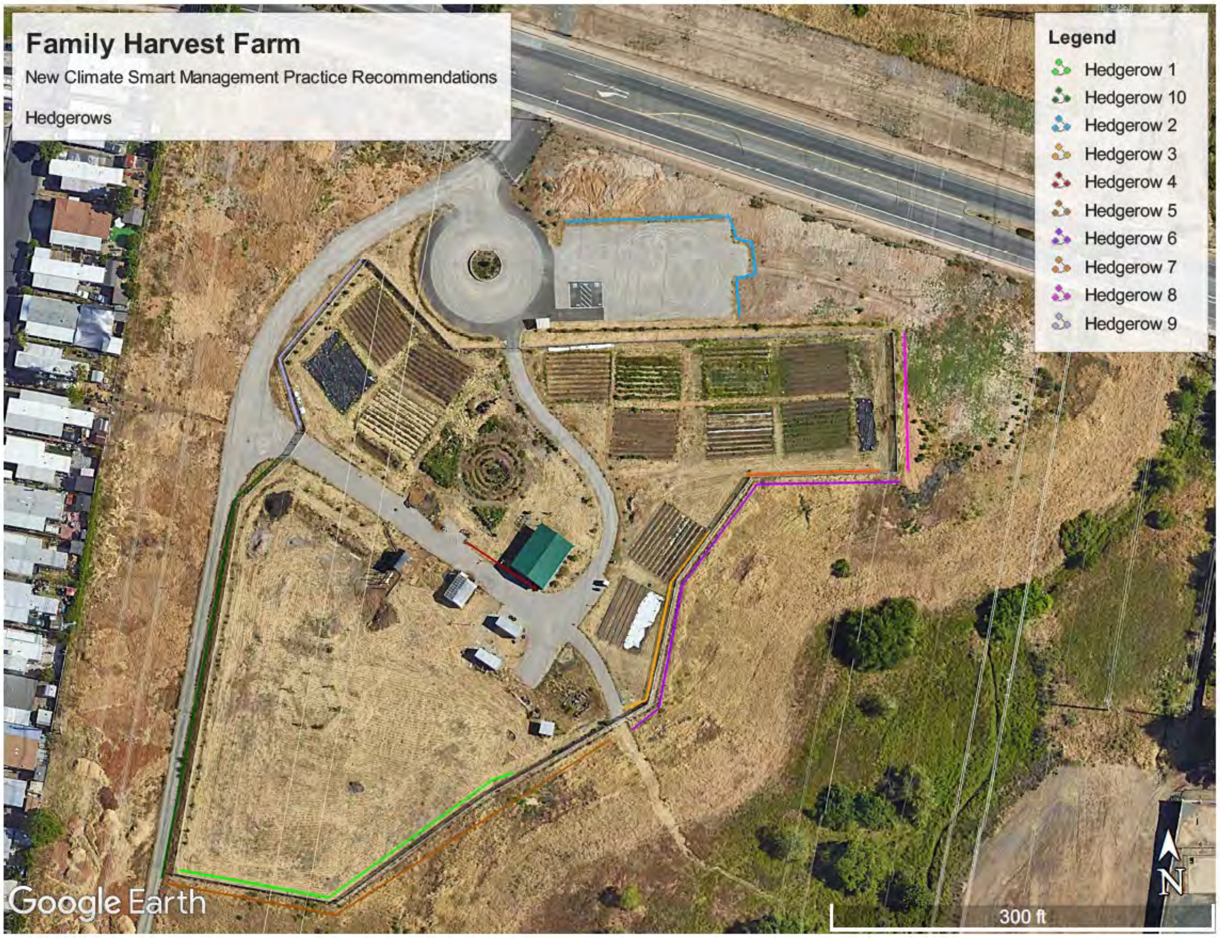
Table 7. Recommended hedgerow names, locations, and length.

Hedgerow Name	Hedgerow Location	Hedgerow Length
1	North of Southern Fence Boundary	294 feet
2	Along Northern and Eastern Edge of Parking Lot	228 feet
3	East of Plot G and H	162 feet
4	South of Teaching Building, North of Greenhouse	66 feet
5	Southeastern corner, outside of fence	389 feet
6	Eastern edge, outside of fence	334 feet
7	South of Plot EN and ES, FN and FS	103 feet
8	Northeastern corner, outside of fence	107 feet
9	Northwestern corner, outside of fence	157 feet
10	Western edge, outside of fence	345 feet
	TOTAL	**2,185 feet**

Additional Resources and Reading Material:

CAFF Hedgerow and Farmscaping for California Agriculture Guide

Calflora Planting Guide



Map 12. Recommended new hedgerow plantings at Family Harvest Farm.

<u>Tillage Management and Conservation Tillage</u>

CCRCD recommends Family Harvest Farm continues to practice residue and tillage management to reach soil health goals, reducing disturbances to the soil as much as feasible while still putting seeds or plantings in the ground. As mentioned earlier, it is the goal of the farm manager to be a no-till operation, or as close to as possible. Weeds and soil health needs have made this difficult to achieve in the first years of management on the farm, but cover cropping, mulch, and compost have made marked improvements in soil structure and health. CCRCD will continue to support the farm manager in reaching these goals.

<u>Additional Resources and Reading Material:</u>
[UC SAREP Conservation Tillage Resources]

<u>Riparian Restoration (Riparian Herbaceous Cover, Riparian Forest Buffer)</u>

In the fall of 2022, PG&E cut a majority of the riparian area southeast of the farm in hopes of avoiding potentially hazardous property fires as part of PG&E's broader vegetation management strategy around high voltage infrastructure. CCRCD recommends working with

PG&E and other partners to re-establish the riparian zone with appropriate native plantings to reduce erosion, slow runoff, increase wildlife habitat, and more. Species selection will need to be verified with PG&E to prevent interfering with high-voltage infrastructure and to ensure that planted trees and plants are not removed by PG&E. To achieve Riparian Restoration, CCRCD recommends implementing two NRCS Management Practices, Riparian Herbaceous Cover and Riparian Forest Buffer.

Map 13. Riparian Restoration location at Family Harvest Farm.

Riparian Herbaceous Cover by NRCS definition is “grasses, sedges, rushes, ferns, legumes, and forbs tolerant of intermittent flooding or saturated soils, established or managed as the dominant vegetation in the transitional zone between upland and aquatic habitats. This practice should provide carbon sequestration benefits in addition to improved habitat for wildlife, improved water quality, reduced erosion, and more.

Riparian Forest Buffers by NRCS definition are areas predominantly covered by trees and/or shrubs located adjacent to and up-gradient from a watercourse or water body. Plantings can also occur within the riparian floodplain zone as drawn above.

CCRCD Staff recommend further investigation in partnership with John Muir Land Trust and PG&E to determine extent and feasibility of this practice across drawn 2.80-acres to ensure plant success and sustainability. Of course, native plant vegetation is already emerging onsite, so restoration efforts may not be as critical. Weed management may be more critical to allow native species to thrive.

Table 8. NRCS eVeg Guide Recommended Easy Plantings for Riparian Herbaceous Cover

Common Name	Scientific Name
Common yarrow	Achillea millefolium
California (Western) redbud	Cercis orbiculata
Blue wildrye	Elymus glaucus
Red fescue (or creeping red fescue)	Festuca rubra ssp. rubra
Great Valley gumweed	Grindelia camporum
Creeping wildrye or Beardless wildrye	Leymus triticoides
Alkali sacaton	Sporobolus airoides
Santa Barbara sedge	Carex barbarae

Table 9. NRCS eVeg Guide Recommended Easy Plantings for Riparian Forest Buffer

Common Name	Scientific Name
Douglas' sagewort (mugwort)	Artemisia douglasiana
Fourwing saltbush	Atriplex canescens
Coyotebrush	Baccharis pilularis
Mule-fat	Baccharis salicifolia
Hollyleaved barberry	Berberis aquifolium
Common buttonbush (California buttonwillow)	Cephalanthus occidentalis
California buckthorn or coffeeberry	Frangula californica
Toyon	Heteromeles arbutifolia
wild mock orange	Philadelphus lewisii
Hollyleaf cherry	Prunus ilicifolia ssp. ilicifolia
Golden currant	Ribes aureum
California wildrose	Rosa californica
Thimbleberry	Rubus parviflorus
California blackberry	Rubus ursinus
Blue elderberry	Sambucus nigra ssp. cerulea
Douglas spiraea	Spiraea douglasii
California wild grape	Vitis californica
Western sweetshrub (spicebush)	Calycanthus occidentalis
Birchleaf mountain mahogany	Cercocarpus betuloides

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Flannelbush	Fremontodendron californicum
Little leaf mock orange	Philadelphus microphyllus

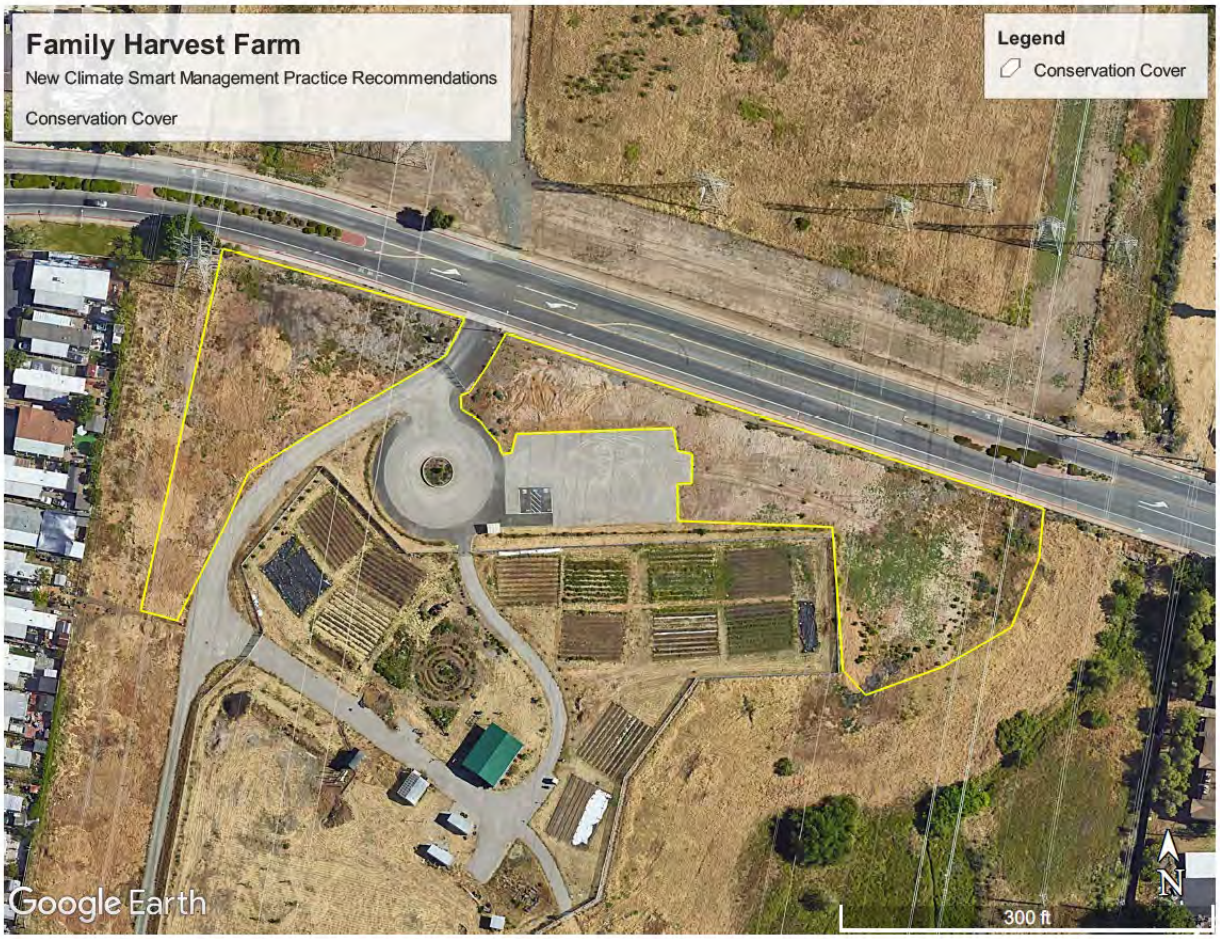
Conservation Cover

Conservation Cover is a management practice that entails establishing and maintaining perennial vegetative cover to protect soil and water resources on lands needing permanent protective cover that will not be used for forage protection. Typically this requires setting aside land and not using it for agricultural production, but can be used in pocket cases of land where agricultural production is not happening for other reasons (access, cost, size, etc.) At Family Harvest Farm, Conservation Cover could be used between the parking lot and Power Ave. Planners have sketched out an approximately 1 acre site that could be seeded with a mix of beneficial perennial native plants that provide stormwater benefits, pollinator habitat benefits, wildlife benefits, and carbon sequestration benefits. Table 10 below lists NRCS eVegGuide recommendations for potential species to plant within the site.

Table 10. NRCS eVegGuide Recommended Plants (Easy, Native) for Conservation Cover

Common Name	Scientific Name
Common yarrow	Achillea millefolium
Douglas' sagewort (mugwort)	Artemisia douglasiana
Showy milkweed	Asclepias speciosa
Mule-fat	Baccharis salicifolia
Hollyleaved barberry	Berberis aquifolium
Clustered field sedge	Carex praegracilis
Ceanothus	Ceanothus spp.
Common buttonbush (California buttonwillow)	Cephalanthus occidentalis
Pipestem	Clematis lasiantha
Western white clematis	Clematis ligusticifolia
Blue wildrye	Elymus glaucus
Yerba Santa	Eriodictyon californicum
Sulphur flower buckwheat	Eriogonum umbellatum
California poppy	Eschscholzia californica
California fescue	Festuca californica
Red fescue (or creeping red fescue)	Festuca rubra ssp. rubra
Great Valley gumweed	Grindelia camporum
Junegrass	Koeleria macrantha
Creeping wildrye or Beardless wildrye	Leymus triticoides
California melic	Melica californica
Deergrass	Muhlenbergia rigens
Hollyleaf cherry	Prunus ilicifolia ssp. ilicifolia
Golden currant	Ribes aureum

Common Name	Scientific Name
Desert globemalow	Sphaeralcea ambigua
Alkali sacaton	Sporobolus airoides
Common snowberry	Symphoricarpos albus var. albus
Pacific aster	Symphyotrichum chilense



Map 14. Recommended Conservation Cover areas at Family Harvest Farm.

Additional Climate Smart Practices for Consideration

<u>Prescribed Grazing/Livestock Incorporation</u>

Family Harvest Farm expressed interest in incorporating livestock (smaller goats, sheep, etc.) into the farm to use for weed management and provide animal husbandry skills to farm apprentices. Livestock incorporation yields secondary carbon benefits, mostly as a result from decreased reliance on fossil fuels and emissions to manage weeds and other farm vegetation. However, given the size of the farm and riparian channel, and lack of livestock infrastructure (fences, water sources, etc.) further investigation is needed in consultation with livestock and grazing experts.

Future Land Use on Other Parts of Parcel

Outside of the fenced area, there is significant land that is currently vegetated with non-native annual grasses and invasive weeds that could be better managed for carbon sequestration should Family Harvest Farm or PG&E desire. While hard to prescribe anything for this area without specific goals of PG&E for fire mitigation, there is potential in these areas to enhance soil health, sequester carbon dioxide, and improve the habitat value of the parcel without greatly increasing the potential for wildfire.

Table 11. Family Harvest Farm Potential Climate-Smart Ag Practices

Climate-Smart Agricultural Management Practice and NRCS Conservation Practice Number	CO_2e Sequestered Annually (tonnes CO_2 equivalent/year)	Co-Benefits
Cover Crop – CPS 340	0.54	Improved soil organic matter, soil fertility, increased soil moisture holding capacity, increased drainage, weed suppression
Hedgerow (CPS 422)	4.35	Provide habitat for wildlife, improve microclimate, stabilize soils, improve water quality and habitat diversity, reduce water loss
Compost Application to Row Crops (CPS Pending)	6.12	Increase soil organic carbon, Improved soil water and nutrient holding capacity;
Reduced Tillage (CPS 329)	0.30	Reduced labor cost, reduced soil organic carbon loss, improved mycorrhizal health and function
Mulching (CPS 484)	0.28	Improved soil organic matter, soil fertility, increased soil moisture holding capacity, increased drainage, weed suppression
Conservation Cover	0.74	Reduced erosion, increase soil organic matter, increased pollinator habitat
Riparian Forest Cover	5.54	Reduced erosion, reduced discharge into waterways, increased soil organic matter, increased wildlife habitat
Riparian Herbaceous Cover	1.60	Reduced erosion, reduced discharge into waterways, increased soil organic matter, increased wildlife habitat
TOTAL	**19.46**	

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Soil, Water, and Carbon

NRCS suggests that a 1% increase in soil organic matter results in an increase in soil water holding capacity (WHC) of approximately 1 acre inch, or 27,152 gallons of increased soil water storage capacity per acre. A 1% increase in soil organic matter represents roughly 20,000 pounds (10 short tons) of organic matter, or 5 short tons of organic carbon. Table 12 shows estimated additional water storage capacity associated with soil carbon increases on Family Harvest Farm resulting from full implementation of this Carbon Farm Plan over 20 years.

Total estimated additional water storage capacity associated with soil carbon increases on Family Harvest resulting from implementation of the carbon farm plan is estimated to be 1.32-acre-feet, or approximately 430,123 gallons of water over 20 years. This analysis is assumed conservative, yet reveals the potential significance of even small increases in soil carbon storage for overall farm dynamics.

Table 12. Estimated Additional Annual Soil Water Holding Capacity (WHC) at Family Harvest Farm With Carbon Farm Plan Implementation

CONSERVATION PRACTICE(S)	20 YEAR CO2e (Mg)	20 YEAR SOIL ORGANIC MATTER INCREASE (Mg)	ANNUAL WHC INCREASE BY YEAR 20 (AF)
Cover Crops (CPS 340)	10.80	5.89	0.05
Compost Application on Cropland	122.31	66.65	0.61
Hedgerow Planting (CPS 422)	86.96	23.69	0.22
Mulching	5.67	3.09	0.03
Riparian Forest Cover (CPS 391)	110.88	30.21	0.28
Reduced Tillage	5.94	3.24	0.03
Conservation Cover (CPS 327)	14.71	8.02	0.07
Riparian Herbaceous Cover	31.92	3.48	0.03
TOTAL	**389.19**	**14.27**	**1.32**

Discussion

Average annual CO_2e reduction values for Family Harvest Farm are summarized by Table 13. Actual sequestration of CO_2 in response to management interventions and conservation practices are not expected to be linear over time, and are expected to vary annually. Length of time during which practices will sequester carbon also varies among individual practices. Terrestrial carbon sequestration resulting from each practice tends to increase cumulatively to maturity and then tends to decline, though remaining net positive relative to baseline conditions for many years. This underscores the value of periodic renovation of windbreaks and shelterbelts, periodic reapplication of compost, and long-term maintenance of all carbon beneficial practices to maintain high levels of carbon accumulation in the farm system.

Table 13. Summary Table of Carbon Capture Potential on Family Harvest Farm.

CONSERVATION PRACTICE(S)	Annual CO_2e Sequestration	20-year CO_2e Sequestration	80-year CO_2e Sequestration
Cover Crops (CPS 340)	0.54	10.80	43.2
Compost Application on Cropland	6.12	122.31	489.24
Hedgerow Planting (CPS 422)	4.35	86.96	347.82
Mulching	0.28	5.67	22.68
Riparian Forest Cover (CPS 391)	0.74	14.71	58.82
Reduced Tillage	5.54	110.88	443.52
Conservation Cover (CPS 327)	1.60	31.92	127.68
Riparian Herbaceous Cover	0.30	5.94	23.76
TOTAL	**19.46**	**389.19**	**1556.73**

Values presented in the Table 13 are best understood as gross CO_2e sequestered through the implementation of the various on-farm practices at the spatial and temporal scales on the Carbon Farm Plan as a whole. Greenhouse gas emissions associated with these practices are generally accounted for in the models used (COMET-Farm, COMET-Planner, etc.). Exact emissions—and sequestration—achieved from practice implementation at Family Harvest Farm cannot be determined precisely; however, sequestration values presented here are based on conservative estimates and are likely to be exceeded in real world application.

In some cases, rates of accumulation of CO_2e may fall below emission rates, resulting in temporary net increases of greenhouse gasses. For example, initial greenhouse gas costs of compost production or riparian restoration may exceed first year sequestration rates.

Conclusion

There is significant potential for additional greenhouse gas reduction and terrestrial carbon capture at Family Harvest Farm. Through implementation of the conservation practices described above, an estimated 389.18 tonnes CO_2e could be sequestered in soils, as well as above and below ground biomass over 20 years. There is also potential for additional on-farm carbon capture over this period through the reapplication of compost, through the renovation of hedgerows at maturity and through the implementation of other carbon-beneficial practices not currently included in this carbon farm plan.

At 6.12 tonnes CO_2 per year, the annual application of compost to the orchard and row crop systems is the single largest opportunity for greenhouse gas reductions. On a per acre basis, hedgerow planting offers the greatest opportunities for carbon capture and storage in above and below ground biomass over a 20 to 80 year time frame.

Overall, the estimated 389.18 Mg CO_2e which could potentially be sequestered over 20 years is equivalent to greenhouse gas emissions from 83 passenger vehicles driven for one year or 966,025 miles driven by an average passenger vehicle, or the energy use of 49 homes for one year. (USEPA, 2022)

Photo 5. Fava Beans planted as a crop at Family Harvest Farm, taken in March 2023.

Monitoring

Practice monitoring (plant survival, compost applications, soil cover etc.) should be carried out in coordination with annual inspections by Family Harvest Farm staff and/or project managers from the Contra Costa RCD or other organizations involved in project implementation. Soil carbon and other ecosystem services should be monitored in accordance with market or voluntary protocol requirements (if applicable). Baseline data and records of implementation activities, including locations, extent of project(s), dates of implementation, etc. should all be included in plan implementation documentation.

This plan should be viewed as a living document. It should evolve as practices are implemented and new information and new tools become available. Additional carbon-beneficial practices may be considered for inclusion in the plan in the future. Greenhouse gas values presented here as associated with specific practices are considered to be both conservative and based upon the best available information at the time of this plan's preparation (February 2023).

Short Term Action Plan and Phases

Because the scope of the Carbon Farm Plan is extensive, practices are likely to be implemented over time, based upon greenhouse gas and co-benefits, available funds, and farm priorities. Below, CCRCD Staff have prepared a rough short term action plan based on known and anticipated funding sources in the near future (through the end of 2023) that could lead to implementation of parts of this carbon farm plan. CCRCD Staff recommend continuing to engage with the RCD to learn of available opportunities to implement this plan.

Immediately Actionable Items (March 2023)	**Possible Funding Mechanism**
Continued implementation of management practices in new orchard planting	CDFA Healthy Soils Program NRCS Environmental Quality Incentives Program Project Apis M. Seeds for Bees Zero Foodprint/Restore CA
Install hedgerows to expand existing hedgerows	Xerces Society Hedgerow Kits CDFA Pollinator Habitat Grant
Develop pest management plan with CCRCD/UCCE and implement on farm	Contra Costa Fish and Wildlife Committee
Review CDFA Urban Agriculture Grant when available for use to expand farm operations	CDFA Urban Agriculture Grant

Funding and Financial Assistance

All of the management practices recommended are, at a minimum, partially funded through financial assistance programs run through various levels of local, state, and federal governments. In Table 14, CCRCD staff have compiled known programs that could lead to partial or full implementation funding. This list is not exhaustive, and additional funding sources may come to light. CCRCD staff recommend connecting with them to determine the latest status of any of these funding programs or new programs to come.

Table 14. Currently Known or Available Funding for Climate-Smart Agriculture

Funding or Implementation Source	Description
CDFA Healthy Soils Incentives Program (HSP)	Under the CDFA Healthy Soils Incentives Program, farmers can apply through CCRCD for partial cost-share funding to implement climate-smart agriculture practices for three years. In 2021, this program received $67.5 million from the California Budget and received $90 million+ in applications and will likely be funded again.
CDFA Healthy Soils Demonstration Program	Under the CDFA Healthy Soils Demonstration Program, RCDs or other research groups can apply for funding to demonstrate climate-smart agriculture with partner farms and/or research new practices. In 2021, this program received 12 applications for $2 million and funded 7 projects for $1.1 million. This program will likely be funded again, but CCRCD Staff recommend pursuing the Incentives Program.
USDA NRCS Environmental Quality Incentives Program (EQIP)	Under the 2018 Farm Bill, the USDA NRCS is authorized to provide cost-share contracts to farms to conserve natural resources and address ongoing resource concerns. This program will very likely continue on in perpetuity through the federal government.
Xerces Society Hedgerow Kits	The Xerces Society is a non-profit organization with the goal of conserving invertebrates and their habitats. Through the California Monarch and Pollinator Habitat Kits, farms can apply for free hedgerow kits (cover approximately 450 linear ft) to implement on their farm. CCRCD Staff can assist in applications, and potentially in installation depending on available funding.
Project Apis M. Seeds for Bees	Project Apis m. is a non-profit that funds and directs honey bee research to enhance health and vitality while improving crop production. Through the Seeds for Bees program, Project Apis m. provides free cover crop seed to interested farmers to promote pollinator forage. CCRCD staff can assist in applications to this program.

Contra Costa Fish and Wildlife Committee	The Contra Costa Fish and Wildlife Committee provides annual grants from polluter fees and/or hunting tag sales to increase the conservation of wildlife within Contra Costa county. Priorities and funding levels change year to year, but typically the committee is interested in projects that will directly improve habitat quality or restore habitat. While it is unclear if they are interested in farm habitat, this could be a potential source of funding for plants that provide pollinator and wildlife habitat.
Zero Foodprint/Restore CA	Zero Foodprint is a non-profit organization mobilizing the food world around agricultural climate solutions and runs the Restore CA program, a program that provides cost-share funding to farms interested in implementing carbon farm plans and climate-smart agricultural practices. In Summer 2022, Zero Foodprint intends to grant $200,000 to farms throughout California.
CDFA Urban Ag Grant	This program is still being developed by CDFA (as of March 2023) but aims to help urban farmers and community-based organizations by 1) funding urban food system infrastructure (capital equipment purchases, facilities, etc.) and 2) supporting jobs, internships, and professional development opportunities.
USDA Urban Ag and Innovation Grant	The NRCS Urban Agriculture and Innovation Production (UAIP) competitive grants initiate or expand efforts of farmers, gardeners, citizens, government officials, schools, and other stakeholders in urban areas and suburbs. Projects may target areas of food access; education; business and start-up costs for new farmers; and development of policies related to zoning and other needs of urban production.
California Underserved and Small Farm Producer Grant	The California Underserved and Small Farm Producer Grant Program awards competitive grants to facilitate direct assistance to individual small and mid-scale and/or socially disadvantaged farmers and ranchers who need support applying for COVID-19 economic relief grant programs, assistance with business planning and marketing strategies, and drought relief funding. This program has changed over time, meeting the immediate concerns of underserved producers and will likely continue to change in the future.
CDFA Pollinator Habitat Grant	The CDFA Pollinator Habitat Grant Program provides grant funding for the establishment of pollinator habitat on agricultural lands throughout California. CDFA was directed to administer the Pollinator Habitat Program and to prioritize the planning of native habitats for the benefit of native biodiversity and the use of locally appropriate native plant seed mixes when feasible.

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Appendix

A. NRCS Soil Survey
B. Soil Reports
C. Carbon Farm Planning Maps
D. COMET-Planner Report Existing Practices
E. COMET-Planner Report Recommended Practices
F. Recommended NRCS Conservation Practice Standards
G. Compost Monitoring Logs

Appendix F. Recommended NRCS Conservation Practice Standards

The following are recommended management practices under the North Richmond Farm Carbon Farm Plan. We have included relevant NRCS Conservation Practice Standard sheets that provide additional detail and information on each practice. For further information, please contact the Contra Costa Resource Conservation District of the USDA NRCS - Concord Field Office.

- NRCS CPS 327 - Conservation Cover
- NRCS CPS 329 - Residue and Tillage Management - No Till
- NRCS CPS 340 - Cover Crop
- NRCS CPS 390 - Riparian Herbaceous Cover
- NRCS CPS 391 – Riparian Forest Buffer
- NRCS CPS 422 - Hedgerow Planting
- NRCS CPS 484 - Mulching
- NRCS CPS 808 - Soil Carbon Amendment (Draft)

Appendix G. Compost Monitoring Log

Below is a compost monitoring log for thew Family Harvest Farm. For questions about protocols, please refer to the On-Farm Composting Handbook developed by the Northeast Regional Agricultural Engineering Service (1992).

Compost Monitoring Log										
Pile Identification:				Pile Location:				Date Pile Built:		
Feedstocks and Mix Proportions										
Date	Pile Temperature (3 Feet Down)					Air Temp	Moisture Content	Odor	Visual	Notes
	1	2	3	4	5					

Appendix B

Summary of Focus Group and Survey Results

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SALC:

Healthy Lands, Healthy People:

Results from a Participatory

Focus Group Study

on

Carbon Sequestration Opportunities

in

Contra Costa County

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This Qualitative Focus Groups - Study was funded
by a State of California Department of Conservation Sustainable
Agricultural Lands Conservation Grant
to the Office of Sustainability
of Contra Costa County, CA, and is part of
Healthy Lands, Healthy People: A Carbon Sequestration Feasibility Study
Identifying Potential Opportunities for
Carbon Sequestration and Natural Resource Conservation
in Contra Costa.

This project is a collaborative partnership between the
Office of Sustainability of Contra Costa County,
UC Cooperative Extension,
The Contra Costa Resource Conservation District,

This Report was Written By
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Julio Contreras, Guadalupe Gallegos
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Contra Costa County, Office of Sustainability: Jody London

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EXECUTIVE SUMMARY:

Introduction: For the stakeholder engagement part of the *Healthy Lands, Healthy People: Carbon Sequestration Feasibility Study for the County of Contra Costa*, University of California Cooperative Extension in Contra Costa County (UCCE) surveyed and convened focus groups with agricultural practitioners in the county. Our approach considered three distinct agricultural sectors corresponding to distinct land-use patterns, namely, rangelands, croplands, and urban agriculture.

Methods: For each land use type, the structure and content of the surveys and focus group meetings were developed by UCCE advisors with expertise in that sector. The survey content and design were developed collaboratively by advisors with input from the greater project team. The survey and focus groups were publicized to appropriate stakeholders by each UCCE advisor using existing contact lists of potential participants and networks, as well as through affiliate organizations, including the CCRCD and the county, and on multiple platforms of social media. Focus groups were held in person with the exception of the one for rangeland managers and one general meeting held after all others to accommodate those who could not make previous meetings, both of which were conducted virtually via the Zoom™ platform. Stakeholder input and discussions revolved around the importance of increasing local carbon sequestration practices in terms of climate change mitigation, sustainable land use practices, and economic benefits.

Findings: The discussions of the focus groups were generally consistent with survey results. Though there are substantial differences between land use sectors in the perceived opportunities and obstacles to adopting climate smart agricultural practices, the desire for conserving agricultural lands and open space is a significant point of convergence. Survey results showed that most participants were not interested in conservation approaches that would take land out of production use. Most focus group and survey participants already employ some climate smart practices and are interested in learning more about others. All practitioners expressed interest in receiving technical advice about these practices in accessible terms. Practitioners recognize UCCE and CCRCD as important sources of expertise and technical assistance, and desire continued public support for our organizations. Finally, economic incentives are considered essential for making climate smart practices possible for most land use managers. Consistent policies and funding are likely to be key factors for the sustainable adoption of climate smart practices in all sectors.

Recommendations: The *conservation of open space and agricultural lands is by far the most important thing the county can promote to maintain and potentially increase carbon stores* across the county. *Climate smart agricultural practices may enhance carbon capture* on these lands while also *contributing to resiliency* in the face of a changing climate.

There is interest from agricultural practitioners in climate smart practices, but many practitioners feel they are already implementing practices that are economically feasible and work for their operation. While the opportunities and obstacles facing the different sectors of rangeland, cropland, and urban farms are for the most part distinct, in all cases *financial support for implementation and technical assistance are recognized as critical elements to making adoption practical*.

Urban agriculture practitioners are especially attuned to the interconnection of food systems and the environment. *Lack of access to capital and to secure land tenure are major hurdles for urban farmers*, many of them people of color, or from otherwise marginalized groups. Unfavorable local policies also pose obstacles to those interested in producing food in urban limits. This makes it difficult for urban agriculture projects to establish where they are needed most. Contra Costa County can sequester carbon in its diverse communities by increasing land stewardship and increasing land access for low-income farmers and residents. Public support for urban agriculture and green landscapes can provide many co-benefits in addition to carbon sequestration, including local food production, reduced food waste stream through local recycling, enhancement of natural habitats, and social and psychological benefits for residents.

Conclusion: Contra Costa County includes very large and dense urban areas, but also has substantial open spaces and rangeland, and considerable croplands. The vegetation and soils in these working lands and peripheries hold a great deal of carbon. Preserving the agricultural use of these lands and promoting climate smart agricultural practices can enhance their sustainable and productive use while playing a part in the state's climate planning and carbon emissions goals. Increasing urban greening, including urban agriculture, can improve quality of life for residents while raising awareness about climate change and overall reducing the urban carbon footprint. Increasing urban greening and urban agriculture as a part of improving local food systems can lead to multiple health, economic, and social benefits. This is especially needed in neighborhoods that have long suffered from structural inequities, especially in industrial areas, which disproportionately affect people of color. Any plan to enhance carbon sequestration, water conservation, and general sustainability would benefit from an equity lens that rectifies the neglect and exclusion of underserved communities in the county.

1. INTRODUCTION

The *Healthy Lands, Healthy People* carbon sequestration feasibility study is a collaboration between Contra Costa County, the Contra Costa Resource Conservation District (CCRCD), and University of California Cooperative Extension in Contra Costa County (UCCE) to identify opportunities for working lands in Contra Costa County to contribute to California's carbon sequestration goals. The project also has a goal of supporting agriculture in the county, and increasing access to fresh food for county residents.The county also engaged Rincon Consultants to study land use changes and to write a comprehensive report from the contributions of all collaborators. This report summarizes what was learned from stakeholder focus group meetings conducted by UCCE as part of our contribution to the project.

Contra Costa County comprises a diversity of land uses which include extensive working lands serving agriculture, conserving open space, and providing recreation, in addition to large areas of dense urban and suburban development.

As part of the study, UCCE conducted a survey and focus groups with stakeholders in different working land sectors. The goal was to publicize to practitioners the benefits of and opportunities for climate smart agricultural practices that promote carbon sequestration and simultaneously contribute to climate resiliency, to learn the extent to which they were already using such practices, and to identify obstacles to practice adoption. Given that a distinct set of practices apply to each land use type, both the survey and focus groups were customized to engage the interests of their respective practitioners.

2. METHODS

2.1 Overview

UCCE developed and organized the outreach effort with input from Contra Costa County, CCRCD, and Rincon Consultants, with additional input from the Carbon Cycle Institute (a non-profit organization focused on climate and agriculture). Qualitative data were collected by UCCE's Urban Agriculture and Food Systems Program staff and partners via an online survey and discussions from nine focus groups held from May through July of 2022. For each land use type, the structure and content of the surveys and focus group meetings were developed by UCCE advisors with expertise in that sector. Sheila Barry, Livestock and Natural Resources Advisor led outreach for rangelands, Kamyar Aram, Specialty Crops Advisor, for croplands, and Rob Bennaton, Urban Agriculture Advisor, for urban farms and community gardens.

2.2 Survey

The UCCE team created the survey with specific sections pertaining to practices for agriculture sectors corresponding to each land use category. The survey content and design were developed collaboratively by advisors with input from the greater project team. The practices included in the survey were drawn from the National Resource Conservation Service's Conservation Practice Standards, referenced through the California Department of Food and Agriculture's Healthy Soils Program version of the COMET Planner tool (http://comet-planner-cdfahsp.com). We included primarily practices that were relevant to agricultural practitioners in California. The survey was designed for an online interface using the Qualtrics platform. There was a general introductory set of questions that identified the agriculture sector in which respondents practiced and customized subsequent questions in the survey to relevant content. The survey included questions establishing the type and scale of the operation, the primary location of operations, and asked about the level of current employment and potential interest in various, sector-appropriate climate smart agriculture practices, as well as barriers to adoption. A copy of the survey is included in appendix C.

The survey and focus groups were publicized to appropriate stakeholders by each UCCE advisor using existing contact lists of potential participants and networks, as well as through affiliate organizations, including the CCRCD and the county, and on multiple platforms of social media. Copies of fliers and press releases are included in the appendix. A summary of survey results can be accessed in appendix C.

2.3 Focus Groups

Focus groups were held in person with the exception of the one for rangeland managers and one general meeting held after all others to accommodate those who could not make previous meetings, both of which were conducted virtually via the Zoom™ platform. Sites and times of meetings were chosen based on proximity and ease of access for potential participants. For urban agriculture, evening as well as daytime meetings were held to accommodate varying schedules of constituents, and in all parts of the county, with several meetings specifically placed to reach underserved residents Although the focus groups were organized around specific land use-types, participants were encouraged to join any focus group they chose.

Stakeholder input and discussions revolved around the importance of increasing local carbon sequestration practices in terms of climate change mitigation, sustainable land use practices, and economic benefits. Each focus group meeting followed the following general structure:

1. Introductions of presenters, partners, and participants.
2. For urban agriculture meetings, a garden tour was offered before the meeting.
3. An introduction of the SALC project by the County Sustainability Coordinator.
4. A slide presentation explaining carbon sequestration science and climate smart practices.
5. Whole-group or break-out (depending on the number of attendees) discussions
6. A whole group summary of the discussions.

In initiating focus group discussions, the primary questions posed were:

1. What are perceived needs for climate smart practices (climate resiliency, soil health, community resiliency, etc.)
2. What practices are you currently employing?
3. What practices are of interest and what are the resources that would help you implement them? What barriers are there to adopting them?
4. Are there other opportunities to capture carbon on your land or neighborhoods?
5. What policies or government programs might help you initiate these practices?

3. FINDINGS

The discussions of the focus groups were generally consistent with survey results. Though there are substantial differences between land use sectors in the perceived opportunities and obstacles to adopting climate smart agricultural practices, the desire for conserving agricultural lands and open space is a significant point of convergence. Survey results showed that most participants were not interested in conservation approaches that would take land out of production use. Most focus group and survey participants already employ some climate smart practices and are interested in learning more about others. All practitioners expressed interest in receiving technical advice about these practices in accessible terms. Practitioners recognize UCCE and CCRCD as important sources of expertise and technical assistance, and desire continued public support for our organizations. Finally, economic incentives are considered essential for making climate smart practices possible for most land use managers. Consistent policies and funding are likely to be key factors for the sustainable adoption of climate smart practices in all sectors.

Rangeland*:* Practices that may increase carbon sequestration on rangeland include *grazing management, compost application, and increasing woody vegetation* including increasing riparian canopy and oak woodland and other perennial plants through planting or management. While rangelands support livestock production, mostly beef cattle in Contra Costa County, they also provide critical habitat for threatened and endangered species, including Contra Costa Goldfields, Alameda Whipsnake, California Red-Legged Frog, and California Tiger Salamander. Grazed rangelands can also mitigate fire risk. Carbon sequestration practices must be considered in the context of the land's capability and other conservation objectives to be appropriately applied. These management practices are not one-size-fits-all but site- and circumstance-specific. Funding is also required to implement practices that increase carbon sequestration on rangeland as these practices provide little economic return and are typically very expensive relative to production values.

Grazing management, along with weed management and rangeland planting can work to maintain vegetation cover, influence species composition, and keep plants growing longer to sequester carbon. It can also reduce fuel loads and thereby potentially prevent wildfire emissions. Good grazing management that meets habitat conservation goals and also sequesters carbon is already widely practiced in the county.

Compost has not been applied to rangelands in Contra Costa County. Its impact to native plants and habitat is of concern to most rangeland owners and habitat managers. On previously farmed areas being returned to rangeland, the application of compost may contribute to increasing carbon sequestration, but this conversion is only occurring on very limited acreage. More information is needed about the long-term effects of compost application on natural working lands providing habitat

Tree planting or protection of trees on grazing lands has been widely practiced on oak woodlands or other forested grazed lands in the county, but trees on open grasslands may not be appropriate for habitat nor supported by soils or water availability. Historically there have been numerous restoration projects on rangelands, particularly willow and oak tree protection and plantings, and seeding. These projects are generally done in appropriate sites and with care have successfully established and are working to sequester carbon. Because the benefits of restoration and conservation projects may not necessarily be immediately apparent, there is also a need to communicate positively about the success of these projects and provide funds to monitor their efficacy.

Three respondents completed the rangeland survey sufficiently for inclusion. These represented a range of geographical locations in the county and in acreage managed. Tree planting and habitat restoration received the most positive responses. Overall, the number of times "need more information" was selected suggests many opportunities for continued engagement. Logistical and fiscal obstacles to implementation of carbon sequestering practices were identified by a majority of respondents. Cost and personnel were identified as substantial barriers by all respondents, but all were also open to considering the practices listed if financial support were to be provided.

The rangeland focus group discussion focused on what policies are financially feasible and which rangeland sites could benefit from carbon sequestration practices. One participant asked what could be done on an individual level regarding carbon – what is the equivalent of turning off water when brushing teeth for water conservation, on rangelands? A representative from the East Bay Municipal Utility District spoke to the success of riparian restoration on their lands through planting trees from cuttings. It was noted that these approaches are very dependent on site factors.

It was noted that across the state millions of dollars are being provided to remove trees that have died from drought, or been infested with pests and diseases, which doesn't seem to be promoting carbon sequestration. However, there is still a need to restore and maintain oak woodlands.

The cost of implementing grazing and rangeland management practices intended to increase carbon sequestration when there is not a guarantee of the success of these management practices is a concern expressed by rangeland managers. In answer to this concern, one manager who has been doing habitat restoration for more than 30 years, felt the science is there for certain practices including managing grazing to enhance and restore riparian. There is less evidence of the value and success in native seed planting for enhanced carbon sequestration. It was pointed out that native seed planting, for example, can easily cost $30,000/acre so without substantial subsidies ranchers and land managers will not implement this practice. The cost of compost application also has similar economic challenges and as previously noted there are concerns about the compatibility of this practice with habitat management goals.

***Croplands**:* Cropland managers generally understand and to some extent practice conservation strategies, such as farmland preservation, nutrient management, organic amendment application, cover cropping, reduced tillage, and establishing hedgerows and windbreaks. Our discussion suggested that education may make the connection between these practices and carbon sequestration more clear, especially in terminology of plant biology and chemistry familiar to growers and crop service professionals. Particularly, highlighting the central role of carbon in the beneficial effects of soil-building practices can remind crop managers that good soil management and climate smart agriculture are practically the same, and are also an essential part of effective water management, too. The croplands focus group included a presentation by Jonathan Wachter of the Carbon Cycle Institute which demonstrated the benefit of communicating these connections more clearly. Farmer to farmer extension, facilitated by extension practitioners, such as UCCE and CCRCD, including through multimedia presentations, such as videos, can be a part of overcoming grower hesitations and doubts about the practicability of these strategies. It is also indispensable to demonstrate the economic feasibility of implementing climate-smart practices, including the availability and justification for public cost-share programs that defray costs. Nevertheless, some practices, such as reduced tillage in annual systems, will likely face considerable resistance due to conflict with current cultivation models, for example, the need to have a ready seed bed in early spring to meet contract obligations for harvest in vegetable crops.

A grower participating in the focus group shared that he already engaged in the following land management practices: farmland preservation; nutrient management; organic amendments (including compost, mulch, and whole orchard recycling); cover crops; reduced tillage; perennial cover (including hedgerows, windbreaks, and riparian restoration); and energy efficient equipment. The proposed use of reduced tillage was met with some pushback while the application of compost amendments and cover cropping were seen as more desirable when understood to be economically beneficial to the grower. Nutrient management was discussed, including how the retention of organic matter builds soil nitrogen and reduces nitrous oxide emissions, an effect of fertilizer application. As an alternative to burning the woody biomass of an orchard past its productive life, chipping and applying the residue to the orchard ("whole orchard recycling") was discussed in terms of woody biomass management, emissions reduction and soil conservation.

It is helpful to have clear and accessible educational materials about the physical characteristics of soils, soil chemistry, and their effects on soil carbon, moisture retention, water filtration, and nutrient holding capacity. Incorporating climate-smart agriculture approaches into extension programs is one approach to educating farmers. Communicating about practices, strategies, and funding opportunities is helpful to farmers who are increasingly aware of the implications of climate change.

The one in-person participant in the croplands focus group is a recipient of a California Healthy Soils Program grant, specifically to apply compost to his orchards. The ensuing discussion included information about government support programs for various practices. In some cases, it was noted, such government programs' applications are burdensome, and time consuming.

Seven respondents completed the cropland sections of the survey sufficiently for inclusion, three engaged in producing annual crops, and four in orchards and vineyards. Attitudes are generally positive toward fertilizer management, soil amendments (which include compost), and mulching. Many respondents reported already substantially employing these practices. Probably not surprisingly, reduced tillage is more popular with orchard and vineyard respondents when with those growing annual crops, as tillage is less required in perennial cropping systems. Also unsurprising is that most respondents were not interested in practices that would take cropland out of specialty crop production, such as converting to forager biomass crops, as specialty crops generally result in more income per acre. Respondents for orchards and vineyards showed more interest in hedgerow planting and riparian restoration than annual crop producers, but cited logistic and fiscal limitations as barriers. Significantly, all respondents were potentially interested in carbon sequestration conducive practices if financial support were provided.

***Urban Environment and Agriculture**:* Practices that contribute to carbon sequestration that are already in practice in urban agriculture include compost amendments and cover cropping. Amending soil with compost Improves its nutrient and water holding capacity, and under low-till or no-till approaches that are common on urban farms, can increase soil organic matter and support healthy soil biology. The use of wood chip mulches also contributes to soil organic matter and improves moisture retention. There is some use of targeted grazing to manage fuel breaks or to reduce weeds around urban areas. Stable access to land is a critical need for urban agriculture. Conservation easements and assisted purchasing of land (e.g. through land trusts) or through long-term subsidized leases can be pathways to support urban agriculture with a reliable land base. Space for food production is especially needed in neighborhoods that are food insecure. Education is also important to promote sustainability, to teach agricultural practices, and to cultivate an awareness of climate change.

The respondents to the urban section of the survey were overall the most receptive and enthusiastic about carbon sequestering conservation practices. Those identifying as urban farms (typically less than 1 acre) or small, diversified farms (typically 1-20 acres) indicated that they either already practice or want the practice reduced tillage, nitrogen fertilizer management, organic amendments to soil, conservation crop rotation, cover cropping, and mulching. But these respondents were also skeptical (responding “need more information” or “not interested”) about conservation practices requiring land-use change, such as establishing windbreaks and hedgerows. Most indicated that they were “very interested” In soil health practices, and the great majority were open to implementing these practices if funding could be provided. These trends were also reflected in responses for managers of urban landscapes, though naturally many of the agricultural practices did not apply.

In the focus groups, opportunities for obtaining land in urban areas were discussed. Suggestions included: entering into dialogue with owners of multifamily residences about whether they could cultivate green spaces and/or community gardens on apartment properties; identify and restore creekside and open space properties that are underutilized; in downtown settings, develop rooftop gardens; a mosaic of backyard spaces could comprise a distributed way to grow fruit trees.

Community gardens are likewise distributed across the county and could be organized more comprehensively through a singular program the county could support. Organizers may be available through Sustainable Contra Costa’s Leadership Award Program. Community farms could be developed on park lands, utility districts, and empty tracts, and be managed to catch carbon.

Affordable housing which includes green spaces with edible landscaping and gardening represents an important opportunity for enhancing urban agriculture. Such spaces serve multiple purposes including providing shade and public spaces for community gatherings. They can potentially lighten the impact of extreme heat events on residents. Such sites could also provide areas where the community can compost food and garden wastes. Storm water retention through cisterns, berms, and other earthworks can provide some of the water that is essential for making such projects feasible. There is a desire to promote the use of street tree pits designed to detain water, prevent runoff, and release it for slow tree uptake.

Community development, including workforce development, are valued as an essential element for most urban agriculture projects. Urban agriculture projects, such as school gardens, can also serve as models for environmental education. The role of agriculture in the environment can also be integrated into school curricula and community projects, and these projects can be supported with public resources. The success of urban agriculture projects can be enhanced by tapping into existing community networks, such as science education programs, garden clubs, and parent-teacher associations, and faith-based institutions.

Urban focus group participants strongly identified connections between environmental and social justice issues. Of particular concern were challenges of land tenure and policies that restrict agriculture and food distribution. Contra Costa County’s General Plan and Climate Action Plan were identified as opportunities to develop policies more favorable for urban agriculture. In general, participants expressed a wish for community involvement in the development of these policies. For example, "green infrastructure" can be integrated into policies addressing affordable housing. Edible landscapes are often constrained by homeowners’ associations policies. Water conservation is also a critical component of such infrastructure. Participants felt it is important to empower community-based organizations in partnership with schools, universities, faith-based organizations, therapeutic facilities and community gardens.

There is also a desire for greater support from school and city leadership for urban agriculture and community garden projects. Part of the resistance likely includes concerns about fruit trees “causing a

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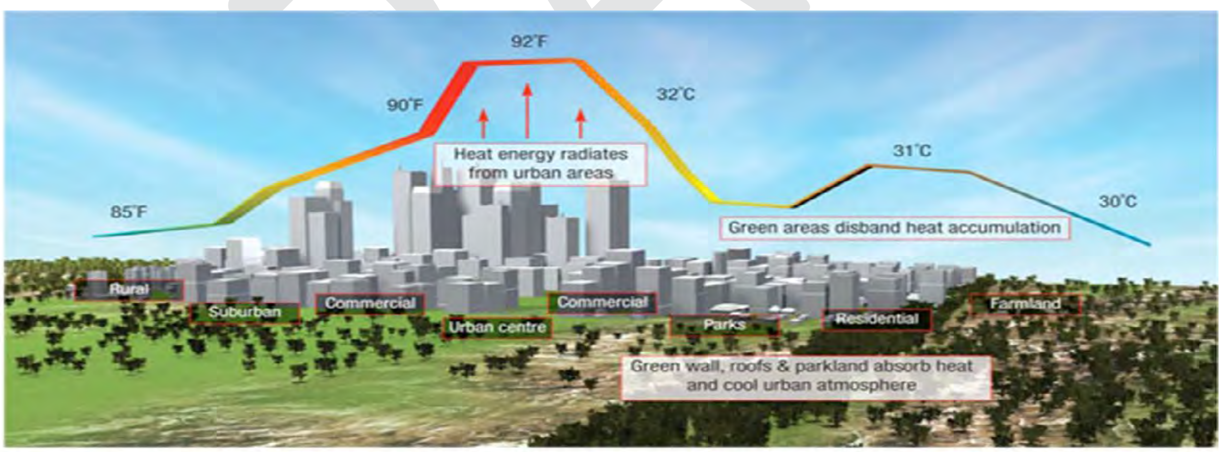
mess" if fruit is not collected, which can also attract pests, such as rodents. Often, funding is not available to support changes in landscape management from ornamental to one that produces food. Certain state funding initiatives (such as the Healthy Soils Program) are unavailable to urban agriculture projects because they are operated by nonprofit organizations. Policies that favor rather than obstruct urban agriculture are called for.

Like much of the globe, Contra Costa County's urban areas continue to grow in population and to expand into surrounding open space. Given that urban areas consume a large amount of resources and therefore have a considerable environmental footprint, green landscapes, if managed sustainably, can to some extent compensate for this disproportionate impact. Urban agriculture has the added benefit of delivering locally produced food and increasing the environmental knowledge of urban residents, while also enhancing mental health and quality of life. Urban farmers, often from historically marginalized groups, typically have difficulty accessing the resources needed to establish or develop urban agriculture projects, especially with respect to the cost and security of land access. Tax credits are an example of how to incentivize investments in small farms. The Sustainable Economies Law Center is exploring this approach (see https://www.theselc.org/tax_credits).



http://hisga.com/images/cool-island-tile/image-8.jpg

Reduced Air Quality
- **Increased Ground Level Ozone**
- **Increased Ambient Air Temperatures**
- **Increased Fine Particulate Matter**

Reduced Water Quality
- **Reduced Water Quality**
- **Reduced Dissolved Oxygen**
- **Increased Waterway Pollutants**

3. RECOMMENDATIONS

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Urban developments, by their nature of hosting dense populations, are major sources of carbon emissions. Nevertheless, in Contra Costa County, as is the case globally, urban development is certain to continue to increase. The county nonetheless has a great opportunity to contribute to the state's carbon sequestration goals by preserving its natural and agricultural lands which already hold much carbon in the form of vegetation, and by encouraging and supporting carbon smart agricultural practices that can enhance productivity, resilience, and carbon sequestration in these lands. There are also considerable opportunities within urban limits to increase and improve green landscapes with potentially added benefits of improved food availability for residents, reduction of the food waste stream, and providing an environment that enhances social and psychological well-being of residents.

Cropland and Rangeland

The conservation of open space and agricultural lands is by far the most important thing the county can promote to maintain and potentially enhance carbon stores across the county. Climate smart agricultural practices may increase carbon capture on these lands while also contributing to resiliency in the face of a changing climate.

There is interest from agricultural practitioners in climate smart practices, but many practitioners feel they are already implementing practices that are economically feasible and work for their operation. There are many barriers to implement additional practices. While the opportunities and obstacles facing the different sectors of rangeland, cropland, and urban farms are for the most part distinct, in all cases financial support for implementation and technical assistance are recognized as critical elements to making adoption practical.

Recommendations

a. Support programs including conservation and agricultural easements that work to conserve open space and agricultural land
b. Support and encourage enrollment in state funded incentive programs that fund climate smart practices. county funded incentive program to enhance

Urban Agriculture

Urban agriculture practitioners are especially attuned to the interconnection of food systems and the environment. Lack of access to capital and to secure land tenure are major hurdles for urban farmers, many of them people of color, or from otherwise marginalized groups. Unfavorable local policies also pose obstacles to those interested in producing food in urban limits. This makes it difficult for urban agriculture projects to establish where they are needed most. Contra Costa County can sequester carbon in its diverse communities by increasing land stewardship and increasing land access for low-income farmers and residents. Public support for urban agriculture and green landscapes can provide many co-benefits in addition to carbon sequestration, including local food production, reduced food waste stream through local recycling, enhancement of natural habitats, and social and psychological benefits for residents.

Recommendations:

a. Encourage investment in small farms through tax credits. The Sustainable Economies Law Center is exploring this approach (see https://www.theselc.org/tax_credits). Another example is the

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Shuumi Land Tax, a voluntary contribution to indigenous by those living on their ancestral land (see https://sogoreate-landtrust.org/shuumi-land-tax/).

b. Provide public support for urban agriculture through Urban Agriculture Incentives Zone Act, which incentivizes urban agriculture through property tax assessments in exchange for converting vacant or unimproved property for small-scale production of agricultural crops and animal husbandry through a contract agreement. (see The Urban Agriculture Incentive Zones Act (AB551)
c. Promote the Neighborhood Food Act of California (AB 2561), a 2014 California law that removes some barriers for renters and homeowners' associations (HOAs) members who want to grow food for themselves at home.
d. Provide county land for local urban agriculture. Models for this approach include Happy Lot in Richmond which is on a vacant lot that is on the city's auction list. Such projects can host volunteer workdays, food giveaways, a seed library, cultural events, and more in neighborhoods that lack park space.
e. Support agriculture education, from K-12, and through community colleges, and vocational education to improve agriculture literacy and prepare youth for all jobs relating to the food system.

4. CONCLUSION:

Contra Costa County includes very large and dense urban areas, but also has substantial open spaces and rangeland, and considerable croplands. The vegetation and soils in these working lands and peripheries hold a great deal of carbon. Preserving the agricultural use of these lands and promoting climate smart agricultural practices can enhance their sustainable and productive use while playing a part in the state's climate planning and carbon emissions goals. In addition, there are many opportunities for even urban communities to be a part of these solutions. Increasing urban greening, including urban agriculture, can improve quality of life for residents while raising awareness about climate change and overall reducing the urban carbon footprint.

Increasing urban greening and urban agriculture as a part of improving local food systems can lead to multiple health, economic, and social benefits. This is especially needed in neighborhoods that have long suffered from structural inequities, especially in industrial areas, which disproportionately affect people of color. Any plan to enhance carbon sequestration, water conservation, and general sustainability would benefit from an equity lens that rectifies the neglect and exclusion of underserved communities in the county.

APPENDICES

Appendix A: FOCUS GROUP FLYERS

Focus Group Flyer (English)
SALC_Flyer_FINAL_5-26-22.pdf

Focus Group Flyer (Spanish)
SALC_Flyer_FINAL_Spanish_5-26-22.pdf

Appendix B: SALC PROJECT PRESS RELEASE
SALC Press Release_Focus _5-11-22.pdf

Appendix C: SURVEY
Qualtrics_SALC_Survey_FINAL.pdf

Survey QR code (links to online version)
SALC_QR Code link to QualtricsSurvey_SV_73TKY8H47XBokom-qrcode.png

Survey results summary
https://drive.google.com/file/d/1wKN-dxaCZ-x5I9W9Vfogv1aAiCEelJpW/view?usp=drive_link

Appendix D: FOCUS GROUP DISCUSSION NOTES
Raw notes from Discussions
SALC_FocusGroupMeetingNotes_Compiled

Appendix E: FOCUS GROUP POWER POINT PRESENTATION
SALC_UCCE Focus Group Presentation_UrbanAgGroups (2)

The survey consisted of separate sections for rangeland and irrigated pasture, annual crops, orchards and vineyards, and urban agriculture(See Attachment A). Out of 120 respondents, 37 completed enough of the survey for their responses to be included in summaries. These included 3 respondents for rangeland, 3 for annual cropland, 4 four orchards and vineyards, and 15 which identified as urban farms, 9 as small, diversified farms, and 5 as landscape mangers. Two respondents completed multiple categories. A discussion of these results can be found in the UCCE focus groups section of this report. The geographical regions named in the tables include: “east county,” indicating the area around the city of Brentwood east of Mt. Diablo and connecting to the Delta agricultural region, where much of the county’s cropland and a substantial amount of rangeland are; the “Diablo Valley,” indicating the valley and foothills region between the eastern side of Mt. Diablo and the western edge of the coastal hills and roughly between the cities of Concord and Danville, “Lamorinda,” indicating the coastal hills region surrounding the cities of Lafayette, Moraga, and Orinda, and the “north shoreline,” indicating roughly the area from the city of Martinez to the city of Antioch, along the shoreline of the San Joaquin River. The western part of the county, around the city of Richmond, is the most densely urbanized and represents the location reported by one third of respondents completing the urban section of the survey,

another third being from the Diablo Valley, with the rest roughly equally divided among the other three regions.

URBAN:

	Urban Farm				
Practices:	Extensively practice	Occasionally practice	Want to practice	Need more information	Not interested
Reduced tillage	6	1	2	1	3
Nitrogen fertilizer management	2	2	2	2	4
Substitute fertilizer with amendments	6	3	3	0	2
Conservation crop rotation	4	3	3	1	1
Cover cropping	6	4	3	1	0
Strip cropping	1	0	1	3	7
Mulching	8	4	2	0	0
Fuel efficient equipment	2	0	2	7	2
Land use:	Currently have	Currently developing	Interested in developing	Need more information	Not interested
Retiring marginal soils	0	0	0	3	6
Convert some land to forage & biomass plantings	0	0	0	2	3
Plant vegetative barriers	0	0	0	2	2
Plant riparian cover	0	0	0	5	2
Plant contour buffer strips	0	0	0	4	5
Plant field borders	0	0	0	5	2
Establish a woodlot	0	0	0	5	3
Establish a windbreak	0	0	0	6	1
Restore a windbreak	0	0	0	8	2
Establish a riparian forest buffer	0	0	0	7	3
Plant a hedgerow	0	0	0	3	4
alley crop	0	0	0	4	5
Multi-story crop	0	0	0	3	6
	Very interested	Somewhat interested	Minor interest	Some curiosity	Not at all
Current interest in soil health practices	14	1	0	0	0
	Yes	Maybe	No		
Would you be interested if you could be funded to implement these practices?	11	1	3		

Table 1. **Summary for *urban farms*, part 1 of 3.** The number of responses for each choice category indicating current practices and attitudes toward carbon sequestering conservation practices for a total of 15 respondents who identified as owners or managers of **urban farms** (completing the ***urban*** section of the survey)**,** typically less than one acre in size.

	Small Farm				
Practices:	Extensively practice	Occasionally practice	Want to practice	Need more information	Not interested
Reduced tillage	5	2	1	1	0
Nitrogen fertilizer management	4	2	0	1	2
Substitute fertilizer with amendments	8	0	1	0	0
Conservation crop rotation	7	1	1	0	0
Cover cropping	6	1	1	0	1
Strip cropping	2	0	0	1	5
Mulching	7	1	1	0	0
Fuel efficient equipment	1	0	2	5	1
Land use:	Currently have	Currently developing	Interested in developing	Need more information	Not interested
Retiring marginal soils	0	0	0	3	3
Convert some land to forage & biomass plantings	0	0	0	4	2
Plant vegetative barriers	0	0	0	1	0
Plant riparian cover	0	0	0	2	2
Plant contour buffer strips	0	0	0	2	4
Plant field borders	0	0	0	2	2
Establish a woodlot	0	0	0	4	1
Establish a windbreak	0	0	0	2	3
Restore a windbreak	0	0	0	4	2
Establish a riparian forest buffer	0	0	0	4	1
Plant a hedgerow	0	0	0	1	2
alley crop	0	0	0	4	3
Multi-story crop	0	0	0	2	4
	Very interested	Somewhat interested	Minor interest	Some curiosity	Not at all
Current interest in soil health practices	8	1	0	0	0
	Yes	Maybe	No		
Would you be interested if you could be funded to implement these practices?	6	2	1		

Table 2. **Summary for *urban farms*, part 2 of 3.** The number of responses for each choice category indicating current practices and attitudes toward carbon sequestering conservation practices for a total of 9 respondents who identified as owners or managers of **small, diversified farms** (completing the ***urban*** section of the survey), typically 1-20 acres in size.

	Urban Landscape				
Practices:	Extensively practice	Occasionally practice	Want to practice	Need more information	Not interested
Reduced tillage	1	3	1	1	0
Nitrogen fertilizer management	1	3	0	0	1
Substitute fertilizer with amendments	3	2	1	0	0
Conservation crop rotation	1	2	1	0	0
Cover cropping	1	2	1	0	0
Strip cropping	0	0	0	1	4
Mulching	2	3	1	0	0
Fuel efficient equipment	1	0	2	4	0
Land use:	Currently have	Currently developing	Interested in developing	Need more information	Not interested
Retiring marginal soils	0	0	0	1	1
Convert some land to forage & biomass plantings	0	0	0	1	1
Plant vegetative barriers	0	0	0	0	1
Plant riparian cover	0	0	0	0	3
Plant contour buffer strips	0	0	0	0	4
Plant field borders	0	0	0	1	1
Establish a woodlot	0	0	0	1	2
Establish a windbreak	0	0	0	0	3
Restore a windbreak	0	0	0	1	3
Establish a riparian forest buffer	0	0	0	1	4
Plant a hedgerow	0	0	0	1	3
alley crop	0	0	0	2	3
Multi-story crop	0	0	0	1	2
	Very interested	Somewhat interested	Minor interest	Some curiosity	Not at all
Current interest in soil health practices	4	0	0	1	0
	Yes	Maybe	No		
Would you be interested if you could be funded to implement these practices?	4	1	0		

Table 3. **Summary for *urban farms*, part 3 of 3.** The number of responses for each choice category indicating current practices and attitudes toward carbon sequestering conservation practices for a total of 5 respondents who identified as managers of **urban landscapes** (completing the ***urban*** section of the survey).

RANGELAND:

Location:	Lamorinda		Diablo Valley		North Shore	
Size:	29,000 acres		320 acres		33 acres	
Role:	Manager		Manager		Owner	
Use:	Public Land / Land Manager		Public Land / Land Manager		Private Land Owner	
Practices:	**Current**	**Potential**	**Current**	**Potential**	**Current**	**Potential**
Irrigated Pasture	-	-	-	-	-	-
Compost application	Want to practice	Need more information	Practice occasionally	Currently have	Not interested	Not interested
Tree planting/restoration	Practice extensively	Currently have	Practice occasionally	Currently have	Want to practice	Want to develop
Hedgerow/windbreak	Not interested	Not interested		Want to develop	Not interested	Not interested
Riparian forest buffer	Practice extensively	Currently have		Want to develop	Need more information	Need more information
Tree/shrub establishment	Not interested	Not interested		Want to develop	Want to practice	Want to develop
Silvopasture	Not interested	Not interested		Want to develop	Need more information	Need more information
Prescribed grazing	Practice extensively	Currently have			Not interested	Not interested
Range planting	Need more information	Need more information		Need more information	Want to practice	Want to develop
Obstacles		Logistical / Operational Conflicts		Fiscal		Fiscal, Logistical / Operational Conflicts, Environmental Conflicts

Table 4a. **Summary for *rangeland, part 1 of 2*.** Background information and responses for three respondents completing the ***rangeland*** section of the survey.

Location:	Lamorinda	Diablo Valley	North Shore
Size:	29,000 acres	320 acres	33 acres
Role:	Manager	Manager	Owner
Use:	Public Land / Land Manager	Public Land / Land Manager	Private Land Owner
How do you see carbon sequestration practices in relation to other conservation practices?			
Habitat conservation	Improves desired outcomes	Improves desired outcomes	Improves desired outcomes
Fire fuels management	No relation	Improves desired outcomes	Improves desired outcomes
Watershed management	Improves desired outcomes	Improves desired outcomes	Improves desired outcomes
What barriers do you see to carbon sequestration practices?			
Cost	Substantial Barrier	Substantial Barrier	Substantial Barrier
Personnel	Substantial Barrier	Substantial Barrier	Substantial Barrier
Expertise	Mild Barrier	Minor Barrier	Mild Barrier
Tools	Mild Barrier	Substantial Barrier	Substantial Barrier
Would you be interested in adopting carbon sequestration practices if financial support were provided?	Maybe	Yes	Maybe

Table 4b. **Summary for *rangeland, part 2 of 2*.** Background information and responses for three respondents completing the ***rangeland*** section of the survey (continued).

CROPLAND:

Location:	East County		Lamorinda		North shore	
Size:	170 acres		29,000 acres (range + forage)		17 acres	
Practices:	Current	Potential	Current	Potential	Current	Potential
Fertilizer management	75 % or more	Need more info	>25%	Not interested	75 % or more	Want to practice
Organic soil amendments	75 % or more		>25%	Want to practice	75 % or more	Want to practice
Cover Cropping	25-50%		>25%	Not interested	75 % or more	Want to practice
Mulching	>25%		>25%	Want to practice	75 % or more	Want to practice
Reduce tillage	>25%		>25%	Not interested	75 % or more	Want to practice
Conservation crops	50-75%		50-75%	Not interested	>25%	Want to practice
Fuel efficient equipment	25-50%		>25%	Not interested	75 % or more	Not interested
Land use:						
Planting hedgerow/windbreak	25-50%	Want to practice	25-50%	Not interested	25-50%	Not interested
Riparian restoration	>25%	Not interested	50-75%	Want to practice	50-75%	Want to practice
Convert to forage or biomass crop			>25%	Not interested	>25%	Not interested
Conservation cover on retired land			>25%	Want to practice	>25%	Want to practice
Would you be interested in carbon sequestration practices if financial support were provided?	Maybe		Maybe		Yes, definitely	

Table 5. **Summary for *cropland, part 1 of 2.*** Background information and responses for three respondents completing the ***annual croplands*** section of the survey.

Location:	East County		East County		Diablo Valley		Lamorinda	
Size:	170 acres		280 acres		20 acres		3.75 acres	
Practices:	Current	Potential	Current	Potential	Current	Potential	Current	Potential
Fertilizer management	75 % or more	Need more info	75 % or more	Want to practice	75 % or more	Not interested	>25%	Not interested
Cover Cropping	25-50%		75 % or more	Want to practice	75 % or more	Want to practice	50%-75%	Want to practice
Mulching	>25%		75 % or more	Want to practice	75 % or more	Want to practice	75 % or more	Want to practice
Reduce tillage	>25%		75 % or more	Want to practice	75 % or more	Want to practice	>25%	Want to practice
Conservation crops	50%-75%		75 % or more	Want to practice	75 % or more	Want to practice	75 % or more	Want to practice
Fuel efficient equipment	25-50%		>25%	Want to practice	75 % or more	Want to practice	75 % or more	
Land use:								
Planting hedgerow/windbreak	25-50%	Want to practice	50%-75%	Want to practice	>25%	Logistic limitation	>25%	Logistic limitation
Riparian restoration	>25%	Not interested	>25%	Not interested	>25%	Logistic limitation	Want to practice	Fiscal limitation
Convert to forage or biomass crop			>25%	Not interested	>25%	Not interested	>25%	Not interested
Conservation cover on retired land			>25%	Not interested	>25%	Want to practice	>25%	Policy limitation
Would you be interested in carbon sequestration practices if financial support were provided?	Maybe		Yes, definitely		Yes, definitely		Yes, definitely	

Table 5. **Summary for *cropland, part 2 of 2.*** Background information and responses for three respondents completing the ***orchards & vineyards*** section of the survey.

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Attachment A

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

English

Introducing the SALC Project

Q1.1. ***Did you know that conservation practices you may already be doing are supported by existing government incentives?***

State and federal government programs, as well as non-governmental organizations, are paying farmers, ranchers and foresters to implement resource conservation practices (ecosystem service payments). A prime example is the California Department of Food and Agriculture's Healthy Soils Initiative.

The following survey is the initial step in our California State-funded Sustainable Ag Lands Conservation (SALC) project, ***Healthy Lands, Healthy People***, to assess the potential for growers, ranchers, urban/community farmers and tree stewards in the county to reduce operational costs while increasing ecosystem services. The aim is that participants can both benefit from these incentive programs *and* advance state and national priorities for climate solutions. *You may directly benefit from future implementation projects resulting from this project.*

Healthy Lands, Healthy People, a SALC-funded Carbon Sequestration Feasibility Project, is being

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conducted by Contra Costa's Office of Sustainability, the University of California Cooperative Extension Contra Costa and the Contra Costa County Resource Conservation District. By completing this survey, you will help us to build connections between California initiatives and Contra Costa County's agricultural communities.

Q2.1. In which Contra Costa County Zip Codes are the lands you make decisions for located? List all that apply.

Zip Code 1

Address (Optional)

Zip Code 2

Address (Optional)

Zip Code 3

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Address (Optional)

Zip Code 4

Address (Optional)

Introductory/General Questions & Land Demographics

Q2.4. What kind of land use do you manage/consult on (check all that apply):

- ☐ Annual Cropland
- ☐ Forage / Hay
- ☐ Orchards & Vineyards
- ☐ Irrigated Pasture
- ☐ Integrated, Diversified Production (e.g. market garden)
- ☐ Rangeland
- ☐ Urban Farms / Trees
- ☐ Built Environment / Urban Landscapes

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Q2.3. How many acres are under your management and/or consultation?

Q2.5.
What is your role with respect to land management (check all that apply):

Owner ☐ Manager ☐ Consultant ☐

Section C: Urban Agriculture / Built Environment

Q3.1. This survey is an opportunity to support Contra Costa County urban farming, orchardy, and landscape management. Your survey responses will help us collect data on ways to increase natural resource conservation and reduce operating costs in your growing operation and landscape management. There may be opportunities to create new pathways for supporting urban farmers with programs and carbon sequestration incentives not currently in place.

Q3.2. Do you conduct the following practices?

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	Practice extensively	Practice occasionally	Want to practice	Need more information	Not interested
Reduced tillage	○	○	○	○	○
Nitrogen fertilizer management	○	○	○	○	○
Replacing nitrogen fertilizer with soil amendments	○	○	○	○	○
Conservation crop rotation	○	○	○	○	○
Cover cropping	○	○	○	○	○
Stripcropping	○	○	○	○	○
Mulching	○	○	○	○	○
Improving fuel efficiency of farm equipment	○	○	○	○	○

Q3.3. What potential is there in your operation for implementing the following practices?

	Currently Have	**Currently Developing**	**Interested in Developing**	**Need More Information**	**Not Interested**
Retiring marginal soils (conservation cover)	○	○	○	○	○
Converting some of your land to forage and biomass plantings	○	○	○	○	○
Planting vegetative barriers	○	○	○	○	○
Planting riparian herbaceous cover	○	○	○	○	○

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	Currently Have	Currently Developing	Interested in Developing	Need More Information	Not Interested
Planting contour buffer strips	○	○	○	○	○
Planting field borders	○	○	○	○	○
Establishing a farm woodlot (tree or shrub)	○	○	○	○	○
Establishing a windbreak/shelterbelt	○	○	○	○	○
Renovating or restoring a windbreak/shelterbelt	○	○	○	○	○
Establishing a riparian forest buffer	○	○	○	○	○
Planting a hedgerow	○	○	○	○	○
Practicing alley cropping	○	○	○	○	○
Practicing multi-story cropping	○	○	○	○	○

Q3.4. What tilling intensity do you currently do on your land(s)?

○ Turning soil 2-3 times / year
○ Turning soil 1 time / year
○ Alternating year / section tillage
○ Broadfork as needed
○ No till / minimal soil disturbance

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Q3.5. What is your current level of interest for incorporating practices that support soil health?

- Not at all
- Some curiosity
- Minor interest
- Somewhat interested
- Very interested

Q3.6. Would you be more interested if your organization or company could receive payments for implementing those practices?

Yes Maybe No

Q3.7. What percentage of ag land/soil over the year do you leave unplanted throughout the season?

< 10% 10-25% 25-50% 50-75% 75-100%

Q3.8. What is your level of interest in improving soil healthy by covering land in between harvest?

	1	2	3	4	5
1=Not at all / 5=Cover all possible land					

Q3.9. Are there any riparian or forested areas around your farm that would benefit from habitat enhancement? Who owns the property?

- No
- Yes, I have legal access
- Yes, they are part of the county/city/public utility district
- Yes, they belong to a private business

Q3.10. Would you be interested in supporting the restoration of riparian forest buffer zones or dense vegetation barriers surrounding your farm?

- Not application
- No
- Yes

Q3.11. What is your source of water for crop irrigation? Please check all that apply.

- ◯ Urban / municipal water supply
- ◯ Recaptured / harvested rainwater off of built structures
- ◯ Well water
- ◯ Creek / waterway water
- ◯ Other: [ ]

Q3.12. Does your urban garden / farm use any of these water efficiency practices? (Check all that apply)

- ☐ Rainwater capture
- ☐ Selection of drought tolerant varieties
- ☐ Alternative tillage systems
- ☐ Mulching
- ☐ Drip irrigation
- ☐ Micro-sprinklers
- ☐ Other: [ ]

Q3.13. Do you benefit from any of these environmental services? (Check all that apply)

- ☐ **Woody vegetated buffer:** improves air quality from roadways
- ☐ **Composting:** supports soil biology, increases water / nutrient-holding capacity / reduces organic waste streams

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- [ ] **Biodiversity / habitat enhancements:** hedgerows, butterfly gardens, pollinator patches
- [ ] **Native plant / low water use vegetation**
- [ ] Other:

Q3.14. Would you like to implement any of these environmental services? (Check all that you seek to apply)

- [ ] **Woody vegetated buffer:** improves air quality from roadways
- [ ] **Composting:** supports soil biology, increases water / nutrient-holding capacity / reduces organic waste streams
- [ ] **Biodiversity / habitat enhancements:** hedgerows, butterfly gardens, pollinator patches
- [ ] **Native plant / low water use vegetation**
- [ ] Other:

Q3.15. Would you be interested in adopting Carbon Sequestration practices if financial support were provided?

Not Applicable	Not at all	Maybe	Yes	Yes, definitely
○	○	○	○	○

Q3.16. Can you suggest any change - including knowledge, technology, or policy - that would increase your interest in implementing any of these practices or land uses?

Section B: Cropland

Q4.1. On what percentage of acreage currently under your management or consultation do you practice the following?

	75% or more of acreage (or in development)	**50-75%** of acreage (or in development)	**25-50%** of acreage (or in development)	**Less than 25%** of acreage (or in development)
Fertilizer Management: A nutrient management plan for nitrogren, phosphorus, and potassium that considers the crop reequirements and all potential sources of nutrients.	○	○	○	○
Organic Soil Amendments: Addition of soil amendments as part of fertilization program or for soil improvement	○	○	○	○

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	75% or more of acreage (or in development)	**50-75%** of acreage (or in development)	**25-50%** of acreage (or in development)	**Less than 25%** of acreage (or in development)
Cover Crop: Annual winter or summer cover crop planted between cash crops, or annually seeded or perennial cover between tree or vine rows or permanent beds.	○	○	○	○
Mulching: applying a protective cover of plant residues or other suitable material not produced on the site, to the soil surface.	○	○	○	○
No-till or reduced tillage on annual cropland or in between orchard or vineyard or permanent crop bed rows	○	○	○	○
Conservation Crop: Cash crop rotations that keep the ground covered for greater portions of the year	○	○	○	○
Combustion System Imrovement: Replacing, repowering, or retrofitting agricultural combustion systems and related components or devices (vehicles, irrigation systems, machinery)	○	○	○	○

Q4.2. On acreage under your management or consultation, what do you think is the potential for these

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practices?

	Want to practice, or want to implement more	Need more information about	Limited in practicing by operational/ logistical obstacles	Limited in practicing by fiscal obstacles	Limited in practicing by policy obstacles	Not interested
Fertilizer Management: A nutrient management plan for nitrogen, phosphorus, and potassium that considers the crop requirements and all potential sources of nutrients	○	○	○	○	○	○
Organic Soil Amendments: Addition of soil amendments as part of fertilization program or for soil improvement	○	○	○	○	○	○
Cover Crop: Annual winter or summer cover crop planted between cash crops, or annually seeded or perennial cover between tree or vine rows or permanent beds	○	○	○	○	○	○
Mulching: applying a protective cover of plant residues or other suitable material not produced on the site, to the soil surface	○	○	○	○	○	○
No-till or reduced tillage on annual cropland or in between orchard or vineyard or permanent crop bed rows	○	○	○	○	○	○

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	Want to practice, or want to implement more	Need more information about	Limited in practicing by operational/ logistical obstacles	Limited in practicing by fiscal obstacles	Limited in practicing by policy obstacles	Not interested
Conservation Crop: Cash crop rotations that keep the ground covered for greater portions of the year	○	○	○	○	○	○
Combustion System Improvement: Replacing, repowering, or retrofitting agricultural combustion systems and related components or devices (vehicles, irrigation systems, machinery)	○	○	○	○	○	○

Q4.3. On what percentage of acreage currently under your management or consultation do you have the following land uses?

	75% or more of acreage (or in development)	**50-75%** of acreage (or in development)	**25-50%** of acreage (or in development)	**Less than 25%** of acreage (or in development)
Windbreaks and Hedgerows: Convert strips of cropland to permanent, unfertilized vegetatie cover or woody plants	○	○	○	○
Restore Riparian Areas: planting permanent vegetation, herbaceous or wood	○	○	○	○

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	75% or more of acreage (or in development)	**50-75%** of acreage (or in development)	**25-50%** of acreage (or in development)	**Less than 25%** of acreage (or in development)
Convert Annual Cropland: to pasture, hay, or biomass (e.g., biofuel) production	◯	◯	◯	◯
Conservation Cover On Retired Cropland: Establish and maintain an unfertilized perennial vegetative cover to protect soil and water	◯	◯	◯	◯

Q4.4. On acreage under your management or consultation, what do you think is the potential for implementation of the following land uses?

	Want to practice or want to implement more	**Need more information about**	**Limited in practicing by operational/ logistical obstacles**	**Limited in practicing by fiscal obstacles**	**Limited in practicingy by policy obstacles**	**Not interested**
Windbreaks and Hedgerows: Convert strips of cropland to permanent, unfertilized vegetatie cover or woody plants	◯	◯	◯	◯	◯	◯
Restore Riparian Areas: planting permanent vegetation, herbaceous or wood	◯	◯	◯	◯	◯	◯

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	Want to practice or want to implement more	Need more information about	Limited in practicing by operational/ logistical obstacles	Limited in practicing by fiscal obstacles	Limited in practicingy by policy obstacles	Not interested
Convert Annual Cropland: to pasture, hay, or biomass (e.g., biofuel) production	○	○	○	○	○	○
Conservation Cover On Retired Cropland: Establish and maintain an unfertilized perennial vegetative cover to protect soil and water	○	○	○	○	○	○
Combustion System Improvement: Replacing, repowering, or retrofitting agricultural combustion systems and related components or devices (vehicles, irrigation systems, machinery)	○	○	○	○	○	○

Q4.5. Would you be interested in adopting Carbon Sequestration practices if financial support were provided?

Not Applicable	Not at all	Maybe	Yes	Yes, definitely
○	○	○	○	○

Q4.6. Can you suggest any change - including knowledge, technology, or policy - that would increase your interest in implementing any of these practices or land uses?

Section A: Rangelands / Irrigated Pasture

Q5.1. What is your connection with rangeland in Contra Costa County? (Check all that apply):

Public Land / Land Manager	Private Land Owner	Public Leasee	Private Leasee
☐	☐	☐	☐

Q5.2. Do you manage or use irrigated pasture:

Public Land Owner / Manager	Private Land Owner	Public Leasee	Private Leasee
☐	☐	☐	☐

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Q5.3. Which climate-smart rangeland management practices have you implemented?

	Practice extensively	Practice occasionally	Want to practice	Need more information	Not interested
Compost Application: applied to grazing land @ 6-8 tons/acre	○	○	○	○	○
Tree Planting / Restoration (ex: Oaks)	○	○	○	○	○
Hedgerow / Windbreak: replace grassland with one row of woody plants	○	○	○	○	○
Riparian Forest Buffer: replace strip of grassland near water course	○	○	○	○	○
Tree/Shrub Establishment: convert grassland to a woodlot	○	○	○	○	○
Silvopasture: tree and shrub planting	○	○	○	○	○
Prescribed Grazing: plan grazing to improve rangeland or pasture condition	○	○	○	○	○
Range Planting: seeding forages to improve rangeland	○	○	○	○	○

Q5.4. Which of these rangeland management practices would you like to see implemented on your grazed lands?

	Currently have	Currently developing	Want to develop	Need more information	Not interested
Compost Application: applied to grazing land @ 6-8 tons/acre	○	○	○	○	○

	Currently have	Currently developing	Want to develop	Need more information	Not interested
Tree Planting / Restoration (ex: Oaks)	○	○	○	○	○
Hedgerow / Windbreak: replace grassland with one row of woody plants	○	○	○	○	○
Riparian Forest Buffer: replace strip of grassland near water course	○	○	○	○	○
Tree/Shrub Establishment: convert grassland to a woodlot	○	○	○	○	○
Silvopasture: tree and shrub planting	○	○	○	○	○
Prescribed Grazing: plan grazing to improve rangeland or pasture condition	○	○	○	○	○
Range Planting: seeding forages to improve rangeland	○	○	○	○	○

Q5.5. Were these obstacles related to (check all that apply):

Fiscal	Policy	Logistical / Operational Conflicts	Environmental Conflicts
☐	☐	☐	☐

Q5.6. How do you see Carbon Sequestration practices as they relate to other conservation practices on your land?

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	Improves desired outcomes	Conflicts with desired outcomes	No relation	Do not practice
Habitat Conservation	○	○	○	○
Fire Fuels Management	○	○	○	○
Watershed Management	○	○	○	○

Q5.7. What do you see as barriers to adopting Carbon Sequestration practices?

	Not Applicable	**Not a Barrier**	**Minor Barrier**	**Mild Barrier**	**Substantial Barrier**	**Incompatible with other conservation / land management goals**
Cost to Implement (seeds, plants, compost)	○	○	○	○	○	○
Cost for staff time / personnel	○	○	○	○	○	○
Technical expertise / educational resources	○	○	○	○	○	○
Tools / Equipent	○	○	○	○	○	○
Other(s: [text box]	○	○	○	○	○	○

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Q5.8. Would you be interested in adopting Carbon Sequestration practices if financial support were provided?

Not Applicable	Not at all	Maybe	Yes	Yes, definitely
○	○	○	○	○

Q5.9. Can you suggest any change - including knowledge, technology, or policy - that would increase your interest in implementing any of these practices or land uses?

Name, Contact Info & Individual Demographics

Q6.1. Demographics / Civil Rights (optional)

Race

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Disability

Veteran Status

Age

Gender

Q6.2. Is there anything else you would like to add?

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Appendix C

Countywide Natural and Urban Lands Carbon Potential Sequestration Memorandum

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Contra Costa County
Healthy Lands, Healthy People

Natural and Urban Lands Carbon Sequestration Analysis Results Memo

prepared by

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November 2022

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Attachment A Carbon Sequestration Potential Analysis

Introduction

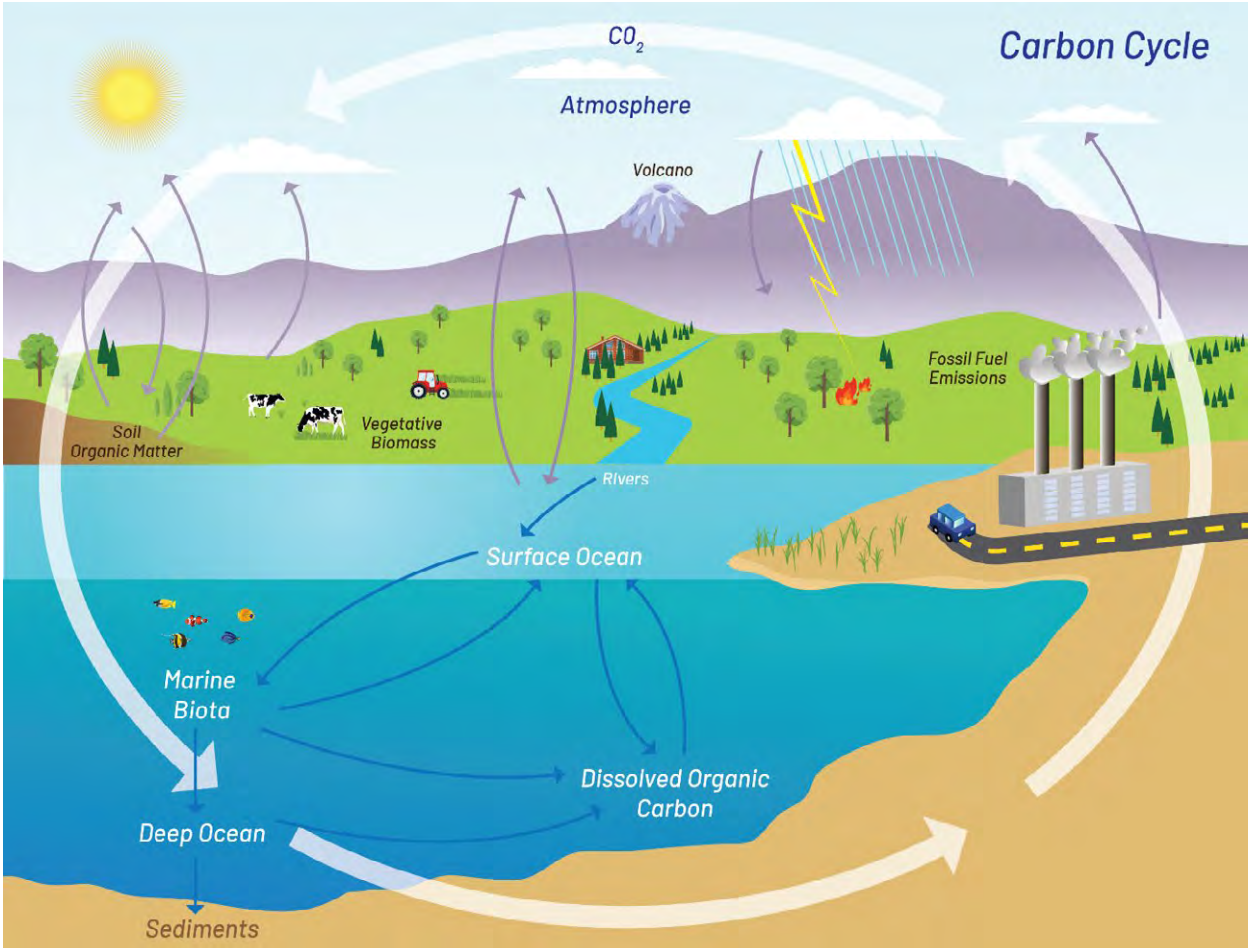
This memorandum describes carbon sequestration potential analysis developed for Contra Costa County's natural and urban lands. The carbon sequestration potential analysis is intended to illustrate opportunities for carbon sequestration on natural and urban lands countywide, through land management activities such as oak woodland restoration and urban forestry. The carbon sequestration potential for working (i.e., agricultural) lands is described in a separate report completed by the Contra Costa Resource Conservation District and Carbon Cycle Institute. This memorandum details the Contra Costa County carbon sequestration potential for natural and urban lands and complementary benefits, and a summary of the results of the quantitative analysis. This analysis along with the working lands carbon sequestration potential analysis will be included in the Contra Costa County Carbon Sequestration Feasibility Report and referenced in the County Climate Action Plan currently being developed by Contra Costa County. These analyses combined provide the County with a full evaluation of carbon sequestration potential for all lands throughout the County.

What is Carbon Sequestration?

Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide.[1] Natural and urban lands play a critical role in sequestering carbon. Biological carbon sequestration occurs as part of the carbon cycle. The carbon cycle is the exchange of carbon between the atmosphere, biosphere (plants, animals, and other life forms), hydrosphere (water bodies), pedosphere (soils), and lithosphere (Earth's crust and mantles, including rocks and fossil fuels). Carbon moves between land types (e.g., forests and grasslands) and carbon pools (e.g., wood, roots, and soils) due to natural processes (growth, decay, and succession) and disturbances (e.g., wildfire) or human-induced disturbances like land use change from natural lands to development or greenhouse gas (GHG) emissions from burning fossil fuels.[2] The carbon cycle is illustrated in Figure 1.

[1] United States Geological Survey (USGS). N.d. What is carbons sequestration? Available <https://www.usgs.gov/faqs/what-carbon-sequestration>. Accessed October, 2022.
[2] California Air Resources Board (CARB). 2018. An Inventory of Ecosystem Carbon in California's Natural & Working Lands. Available: <https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf>. Accessed October 27, 2021.

Figure 1 Carbon Cycle



Regulatory Context

As a global leader in the effort to combat climate change, the State of California has enacted legislation, regulations, and executive orders (EO) that put the state on course to achieve robust emissions reductions and address the impacts of a changing climate. There are several bills that address emissions reductions and play a role in setting the standards for how natural and working lands will help to achieve the State's climate goals.

- **Assembly Bill 32.** On September 27, 2006, the California legislature signed AB 32 – the Global Warming Solutions Act – into law, requiring a reduction in Statewide GHG emissions to 1990 levels by 2020 and California Air Resources Board (CARB) preparation of a Scoping Plan that outlines the main State strategies for reducing GHGs to meet the 2020 deadline.
- **Senate Bill 32.** On September 8, 2021, the California legislature signed SB 32 into law, extending AB 32 by requiring further reduction in Statewide GHG emissions to 40 percent below 1990 levels by 2030.
- **Executive Order N-82-20 to Achieve 30% Land Conserved by 2030 (30x30).** On October 7, 2020, Governor Newsom issued EO N-82-20, which established a new statewide goal of conserving 30% of the state's lands and coastal waters by the year 2030. The order directs The California Natural

Resources Agency, the California Department of Food and Agriculture, the California Environmental Protection Agency, the Governor's Office of Planning and Research, and other state agencies, to identify and implement near- and long-term actions to accelerate natural removal of carbon and build climate resilience in our forests, wetlands, urban greenspaces, agricultural soils, and land conservation activities in ways that serve all communities.

- **Assembly Bill 1279.** On September 16, 2022, Governor Newsom signed into law AB 1279 codifies the State goal to achieve statewide carbon neutrality as soon as possible, and no later than 2045, and establishes an 85% direct emission reduction target as part of that goal. This bill also requires the identification and implementation of carbon dioxide removal strategies to aid in achieving net carbon neutrality.
- **Assembly Bill 1757:** On September 16, 2022, Governor Newsom signed AB 1757 into law, which requires the State to develop an achievable carbon removal target for natural and working lands.

Natural and Working Lands are a key sector in the State's climate change strategy. California's natural and working landscapes, such as forests and farms, are home to the most diverse sources of food, fiber, and renewable energy in the country. These lands underpin the state's water supply and support clean air, wildlife habitat, and local and regional economies. They also comprise a significant carbon stock and the potential to store event greater quantities of carbon. However, they are often the first to experience the impacts of climate change. Thus it is important to deploy strategies to effectively manage natural and working lands, minimize loss due to climate change impacts, and maximize opportunities for increased sequestration.

Though carbon sequestration does not directly reduce a community's GHG emissions, it can complement GHG reduction strategies being implemented in other sectors like energy use and transportation, and contribute to achieving carbon neutrality. All sources of emissions will not be able to be reduced entirely and some sequestration will be required to reach the State's and County's 2045 carbon neutrality target.

Evaluating and Increasing Carbon Sequestration Potential

The County of Contra Costa includes large areas of natural and urban lands and a diversity of land-cover types ranging from developed land to forested lands. Projected population growth may create future land use pressure requiring careful consideration. Achieving success in protecting the existing land based carbon stock and natural and lands involves developing and implementing programs that protect and enhance natural and urban lands, establishing a baseline carbon stock, and measuring and monitoring progress through landscape carbon inventories.[3] While community GHG inventories provide estimates of anthropogenic GHG emissions in a jurisdictional boundary, such as energy use and transportation emissions, a landscape carbon inventory provides an estimate of ecosystem carbon stored in the land.[4] Landscape carbon inventories focus on carbon stored and released from the land, whereas community GHG inventories estimate GHGs emitted from human activities.

Evaluating carbon sequestration potential using landscape carbon inventories and developing feasible sequestration strategies (e.g., restoration and tree planting) complement and support the overall 2030

[3] California Air Resources Board (CARB). 2017. Scoping Plan. Available <https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/scoping_plan_2017.pdf>. Accessed April 14, 2022.
[4] California Air Resources Board (CARB). 2018. An Inventory of Ecosystem Carbon in California's Natural & Working Lands. Available: <https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf>. Accessed October 27, 2021.

Climate Action Plan to meet the goals of AB 1279 to achieve carbon neutrality as soon as possible, and no later than 2045, and maintain negative emissions thereafter. Across the State, cities, and counties are working to sequester carbon and improve the health of natural lands through conservation and carbon sequestration projects, which support State goals in California's Climate Change Scoping Plan to protect and manage natural lands. Examples of plans and projects that have already started to address carbon sequestration in the state include, but are not limited to, the City of San Luis Obispo Climate Action Plan, the Marin Carbon Project, and Sonoma County Ag and Open Space. These plans provide important examples of how to implement carbon stock protection and carbon sequestration strategies at the local level.

This appendix includes a Carbon Sequestration Potential and Complementary Benefits analysis for appropriate natural lands sequestration activities, methodology and results of the carbon sequestration potential and co-benefits analysis for Contra Costa County.

State guidance used to complete the carbon sequestration potential analysis include California's 2017 Climate Change Scoping Plan and the State's Natural and Working Lands Inventory.[5,6,7]

[5] California Air Resources Board (CARB). 2017. California's 2017 Climate Change Scoping Plan. Available: <https://ww2.arb.ca.gov/sites/default/files/classic//cc/scopingplan/scoping_plan_2017.pdf>. Accessed May 26, 2021.

[6] Note: The CARB 2022 Draft Climate Change Scoping Plan was not used as it is still at the draft stage and has not been finalized. Therefore, the CARB 2017 Scoping Plan is still the most current Scoping Plan available. The Draft 2022 Scoping Plan was reviewed, but the 2017 Scoping Plan was the primary Scoping Plan referenced in the production of this memorandum.

[7] CARB. 2018. An Inventory of Ecosystem Carbon in California's Natural and Working Lands. Available: <https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf>. Accessed May 26, 2021.

Carbon Sequestration Potential and Complementary Benefits

The carbon sequestration potential and complementary benefits (co-benefits) analysis for Contra Costa County natural and urban lands was completed following the TerraCount methodology provided in the TerraCount activity sheets, which detail equations for calculating carbon sequestration potential and a qualitative assessment of complementary benefits.[8] The following sections describe the methodology and results of this analysis. These activity sheets provide per acre annual GHG reduction rate and leakage discount[9] (if applicable) to calculate estimated GHG reductions. Users provide total acreage upon which the activity is to be implemented and the duration of the activity. Activities were selected based on their appropriateness for application across relevant land cover types in the county with a conservative range of acres used to derive the carbon sequestration potential for application.

Carbon Sequestration Potential

The results from the Contra Costa County land-cover analysis, landscape carbon inventories, and landscape carbon forecast were used to estimate the future carbon sequestration potential countywide.[10] This carbon sequestration potential and complementary benefits analysis used the estimation of GHG reductions provided in the TerraCount activity sheets.[11] Below is the urban forestry example of the parameters and equation provided in the TerraCount activity sheets.

Table 1 TerraCount Activity Sheet Carbon Sequestration Equation Example

$$Total\ Estimated\ GHG\ Reductions = R * I * D * (100\% - L)$$

Parameter	Value	Unit
R = Per acre annual reduction rate	133.136	t CO_2e/acre/year
I = Total increase in canopy cover acreage within activity area	[Different per activity]	Acres
D = Duration of activity	6	Years
L = Leakage discount	0	Percent

Notes: reproduction of an example equation and variables from the TerraCount Activity Sheets

[Different per activity] = To be determined by user. See Attachment A.

The duration of all activities (*D*) was assumed to be 6 years due to an assumed implementation starting year of 2024 and lasting through 2030. See Attachment A for calculations.

[8] The TerraCount model was not run due to technical constraints, and instead, TerraCount activity sheets were used to calculate carbon sequestration potential, similar to other jurisdictions, including the SANDAG region. TerraCount. N.d. Appendix L Activity Sheets. Available <https://maps.conservation.ca.gov/TerraCount/downloads/>. Accessed March 26, 2022.

[9] The leakage definition used in the TerraCount activity sheets is: "Carbon leakage refers to the displacement of greenhouse gas (GHG) emissions from one place to another due to emission reduction activities. It is caused by a direct or indirect shift of activities that create those emissions from within an emissions accounting system to out of that system." This definition is from Henders and Ostwald (2012) in their review of leakage accounting mechanisms from both the published literature and existing project accounting standards.

[10] Countywide sequestration potential includes all lands including incorporated and unincorporated areas.

[11] TerraCount. N.d. Appendix L Activity Sheets. Available <https://maps.conservation.ca.gov/TerraCount/downloads/>. Accessed March 26, 2022.

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Management Activities

The carbon sequestration activities for natural and urban lands are included in this analysis. The activities, or practices, and low and high implementation levels are shown in Table 2. The total acreage upon which the activity is to be implemented for natural and urban lands activities was estimated based on the Merced County pilot project (for which TerraCount was developed) and adjusted to reflect more feasible implementation levels based on jurisdictional control of lands, stakeholder feedback, or other considerations (for example, fuel reduction to forested lands implementation scenario was determined using the East Bay Park District Wildfire Hazard Reduction Management Plan Wildfire Hazard Assessment and Treatment Areas study of very high fire hazard zones[12]). The total implementation acreage estimates in the table below represent the potential area over which climate smart activities may be implemented over the 6 year implementation period between 2024 and 2030. More detailed descriptions of each management activity can be found on the TerraCount website and in the TerraCount appendices.[13]

Table 2 Carbon Sequestration Activities

Activity	Description	Low Total Implementation (Acres)	High Total Implementation (Acres)
Natural Land			
Restoration of Native Grasses	Restoration of native grasses	7,742	23,226
Oak Woodland Restoration	Restoration of oak woodlands (across the ranges of blue oak and valley oak) in areas where present-day land cover is grassland or other candidate land cover classes	7,742	23,226
Riparian Restoration	Restoration of woody riparian vegetation in areas near streams and rivers	60	120
Fuel Reduction	Fuel treatment to remove excess biomass from forested areas	6,533	17,421
Urban Land			
Urban Forestry	Planting of trees in urban areas, resulting in increased urban tree canopy cover	1,260	3,150

Results

The results of the carbon sequestration potential analysis are provided in Table 2 and Figure 2. Figure 2 shows the average annual carbon sequestration potential for natural and urban lands. The activity with the greatest carbon sequestration potential is urban forestry, followed by oak woodland restoration, and restoration of native grasses. The urban forestry activity includes carbon sequestration estimates for both planting new trees and maintaining existing trees. The high carbon sequestration potential of

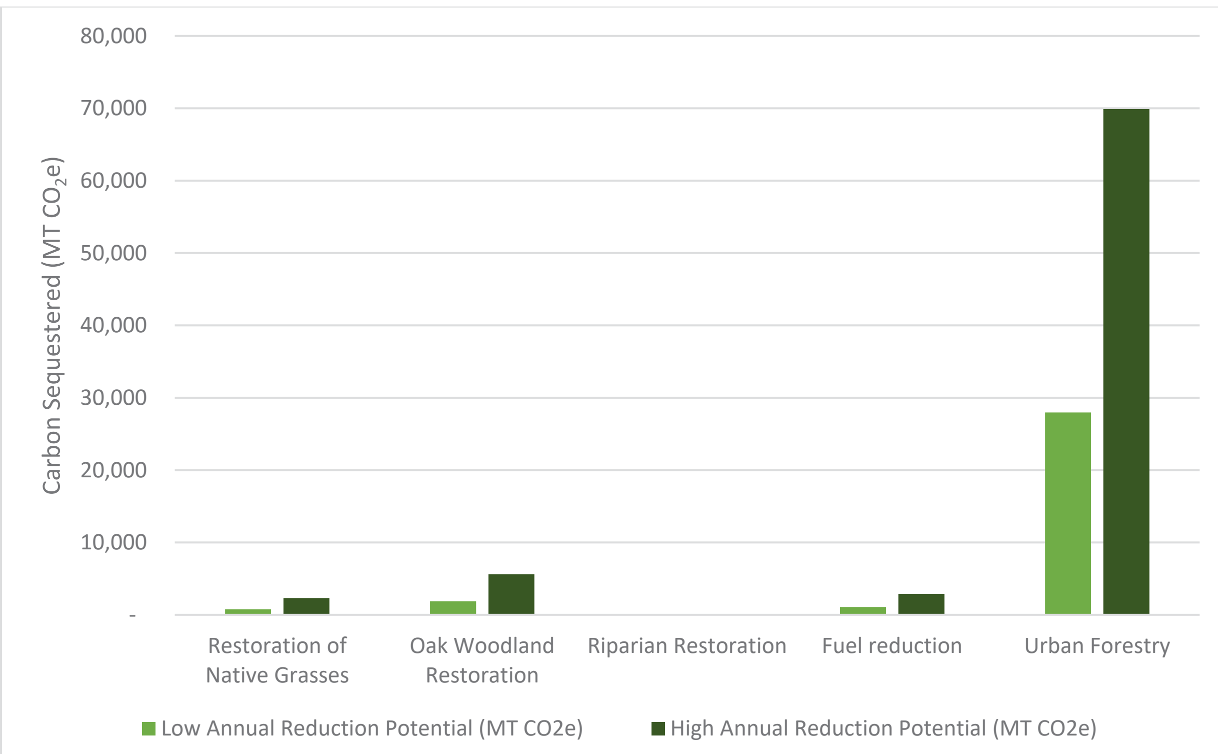
[12] East Bay Park District. 2010. Wildfire Hazard Reduction Management Plan – Appendix C: Hazard Assessment and Treatment Areas. Available <https://www.ebparks.org/sites/default/files/WHRRMP-Appendix_C_-_Hazard_Assess_and_Trtmt_Areas.pdf>. Accessed October 16, 2022.
[13] California Department of Conservation. N.d. TerraCount GHG Activities. Available <https://maps.conservation.ca.gov/terracount/>. Accessed April 14, 2022.

urban forestry is due to a combination of low leakage risk,[14] high per acre annual reduction rate compared to other activities included in the analysis.

Table 2 2030 Carbon Sequestration Potential by Activity

Activity	Low Implementation Sequestration Potential (MT CO_2e/Year)	High Implementation Carbon Sequestration Potential (MT CO_2e/Year)
Natural Land		
Restoration of Native Grasses	773	2,320
Oak Woodland Restoration	1,871	5,613
Riparian Restoration	7	15
Fuel Reduction	1,089	2,904
Urban Land		
Urban Forestry	27,957	69,983

Figure 2 Annual Natural and Urban Lands Carbon Sequestration Potential by Activity



[14] The leakage definition used in the TerraCount activity sheets is: "Carbon leakage refers to the displacement of greenhouse gas (GHG) emissions from one place to another due to emission reduction activities. It is caused by a direct or indirect shift of activities that create those emissions from within an emissions accounting system to out of that system." This definition is from Henders and Ostwald (2012) in their review of leakage accounting mechanisms from both the published literature and existing project accounting standards. In other words, leakage is the release of GHG emissions from implementation of an emissions reduction activity.

Complementary Benefits

Sequestering carbon is just one of the many benefits that are provided by natural and working lands. Efforts to increase carbon storage must consider the potential impacts, both positive and negative, on other benefits, known as complementary benefits (co-benefits). Assessing co-benefits of different management activities allows for prioritization of these activities based not only on carbon sequestration potential, but other important factors, for example agricultural quality, human well-being, water quality, and air quality. In addition to providing estimation of GHG reductions potential, the TerraCount activity sheets also provide a qualitative analysis of complementary benefits. For each activity, the TerraCount activity sheets determine whether the activity would have a positive, negative, positive or negative (depending on site conditions), or no effect on the co-benefits analyzed. Each co-benefit provides an equal score of +1, -1, or 0. These scores are then totaled to provide an overarching co-benefit score for each activity. The co-benefits affected by the activities included in this analysis are provided below.

- **Human wellbeing**
  - Air Quality – estimates air pollution (nitrogen dioxide - NO_2, sulfur dioxide - SO_2, carbon dioxide - CO_2, ozone - O_3, particulate matter 2.5 - PM2.5, and particulate matter 10 - PM10) removed by plants, mainly by uptake through the stomata of leaves
  - Scenic Value – visibility of areas developed from public areas, parks, and roadways
  - Flood Risk Reduction – tracks acreage of development in the 100-year floodplain
- **Water quality**
  - Ag/Urban Water Conservation – changes in water use driven by land use change
  - Water Quality – changes in the chemical, physical, and biological characteristics of water important for ecological and human health
  - Groundwater Recharge Potential – changes in groundwater recharge from scenarios that convert natural lands to development
  - Watershed Integrity – estimated based on the following metrics: riparian areas degraded, important riparian buffer, and natural catchment
- **Biodiversity**
  - Terrestrial Connectivity – species movement potential
  - Natural Habitat – area of natural habitat
  - Priority Conservation Areas – landcover in priority conservation areas (The Nature Conservancy priority conservation areas, Audubon important bird areas, and California Department of Fish and Wildlife essential connectivity areas)
  - Terrestrial Habitat Value – terrestrial habitat value for mammals, birds, amphibians, reptiles, and threatened and endangered species
  - Aquatic Biodiversity Value/Richness – landcover in watersheds with important aquatic habitat (as defined by The Nature Conservancy's Freshwater Blueprint)

The co-benefits assessment for the activities included in this analysis are provided in Table 3. The analysis is qualitative and the extent of actual positive effects on co-benefits for practices will depend on site specific conditions.

Table 3 Co-benefit Assessment

Activity	Human Wellbeing	Water Quality	Biodiversity	Co-benefit Score
Natural Land				
Restoration of Native Grasses	N/A	N/A	N/A	0
Oak Woodland Restoration	Air Quality (+)	Water Quality (+)	Natural Habitat Area (+), Priority Conservation Areas (+), Terrestrial Habitat Value (+/-)	+4
Riparian Restoration	Air Quality (+), Scenic Value (+), Flood Risk Reduction (+)	Water Quality (+), Watershed Integrity (+)	Terrestrial Connectivity (+), Natural Habitat Area (+), Priority Conservation Areas (+), Terrestrial Habitat Value (+/-), Aquatic Biodiversity Value/Richness (+)	+9
Fuel Reduction	N/A	N/A	N/A	0
Urban Land				
Urban Forestry	Air Quality (+), Scenic Value (+)	Watershed Integrity (+)	Terrestrial Connectivity (+), Natural Habitat Area (+), Terrestrial Habitat Value (+)	+6

Note: N/A indicates no effect on the co-benefits analyzed. The TerraCount co-benefits analysis is limited by data availability. N/A does not indicate that no co-benefits exist.

Based on the TerraCount activity sheets, in the natural lands category, riparian restoration provides the most potential for positive effects on co-benefits including air quality, scenic value, flood risk reduction, watershed quality, watershed integrity, terrestrial connectivity, natural habitat area, priority conservation areas, terrestrial habitat value (depending on site conditions), and quality biodiversity value/richness. Oak woodland restoration also provides substantial positive effects on co-benefits including air quality, water quality, natural habitat area, priority conservation areas, and terrestrial habitat value (depending on site conditions).

Urban forestry provides potential for positive effects on air quality, scenic value, watershed integrity, terrestrial connectivity, natural habitat area, and terrestrial habitat value.

Since oak woodland and urban forestry may potentially be applied over a significantly larger number of acres than riparian restoration, these two practices may provide a larger magnitude of co-benefits, even as riparian restoration provides a greater number of co-benefits, assuming full implementation of all practices.

The TerraCount co-benefits analysis has been developed to help prioritize management activities during implementation. It also helps to determine where a practice would be most beneficial to implement. The results of the co-benefits scores are included with the total GHG reduction potential for each management activity in the results below in the *Conclusion* section.

Conclusion

In Contra Costa County, the management practices with the most GHG reduction potential and greatest potential for positive effects on co-benefits in each land cover category (agricultural land, natural land, and urban areas) should be prioritized in 2030 Climate Action Plan implementation. Table 4 details natural lands management and urban forestry activities listed in order of total GHG reduction potential over the six-year implementation period (from 2024 to 2030) and includes a co-benefits score which is the sum of the positive and negative co-benefits identified in Table 3. Agricultural and urban farming activities will be incorporated into the Contra Costa Healthy Lands, Healthy People Carbon Sequestration Feasibility Study Report to produce an overall ranking of sequestration potential and an overall scoring of co-benefits across all climate smart activities and land cover categories. Implementation of these land management activities will require a continual evaluation of local conditions, pursuit of available federal, state, and private funds, and coordination with key partners, to maximize practice adoption achieve the greatest climate resilience and community co-benefits possible. Partnerships with agricultural and natural landowners will be key in ensuring that any barriers to implementation are addressed.

Table 4 Management Activities

Activity	High Total Reduction Potential (MT CO_2e) *	Co-benefit Score
Natural Land		
Oak Woodland Restoration	33,677	+4
Restoration of Native Grasses	13,918	0
Fuel Reduction	17,421	0
Riparian Restoration	90	+9
Urban Land		
Urban Forestry	419,355	+6

* Values are cumulative from the implementation year (2023) to 2030.

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Attachment A

Carbon Sequestration Potential Analysis

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Practice	Emissions Reductions	Leakage	Emissions Reduction	Unit	Land Cover Application	Low Implementation (annual acres)	High Implementation (annual acres)	Low Annual Reduction Potential (MT CO2e)	High Annual Reduction Potential (MT CO2e)	Co-benefits	Activity Notes	Source
Natural Land								**3,740**	**10,851**			
Native grassland restoration	0.799	25.00%	0.60	MT CO2e/Acre/yr	Grassland	1,290	3,871	773	2,320	Activity sheet does not identify any co-benefits associated with this activity		TerraCount Activity Sheets (https://maps.conservation.ca.gov/TerraCount/downloads/Appendix_L_Activity_Sheets_all.pdf)
Oak woodland restoration	1.450	0.00%	1.45	MT CO2e/Acre/yr	Grassland	1,290	3,871	1,871	5,613	**Increase (+)** air quality, water quality, watershed integrity, natural habitat area, priority conservation areas **Increase or Decrease (+/-)** Terrestrial habitat value		TerraCount Activity Sheets (https://maps.conservation.ca.gov/TerraCount/downloads/Appendix_L_Activity_Sheets_all.pdf)
Riparian Restoration	0.996	25.00%	0.75	MT CO2e/Acre/yr	Riparian	10	20	7	15	**Increase (+)** air quality, scenic value, flood risk reduciton, water quality, watershed integrity, terrestrial connectivity, natural habitat area, priority conservaiton areas, aquatic biodiversity value/richness **Increase or Decrease (+/-)** Terrestrial habitat value **Decrease (-)** Crop value (if applied to cropland), Ag/urban water conservation (if applied to cropland)		TerraCount Activity Sheets (https://maps.conservation.ca.gov/TerraCount/downloads/Appendix_L_Activity_Sheets_all.pdf)
Fuel reduction	1.000	0.00%	1.00	MT CO2e/Acre/yr	Forest	1,089	2,904	1,089	2,904	Activity sheet does not identify any co-benefits associated with this activity	*Reduction rate varies by area and is dependent on site specific analysis but Activity Sheet provides R=1 as default value	TerraCount Activity Sheets (https://maps.conservation.ca.gov/TerraCount/downloads/Appendix_L_Activity_Sheets_all.pdf)
Urban Land								**27,957**	**69,893**			
Urban Forestry	133.136	0.00%	133.14	MT CO2e/Acre/yr	Developed/ Urban Forest	210	525	27,957	69,893	**Increase (+)** air quality, scenic value, watershed integrity, terrestrial connectivity, natural habitat area, terrestrial habitat value	*More in-depth analysis with species-specific estimates may be generated through iTree Canopy or other similar model as part of a development of an Urban Forestry Plan	TerraCount Activity Sheets (https://maps.conservation.ca.gov/TerraCount/downloads/Appendix_L_Activity_Sheets_all.pdf)
Total Reductions from Activities (Annual)								**31,697**	**80,744**			
Total Reductions from Activities (2024 - 2030)								**190,185**	**484,461**			

Appendix D

Contra Costa County Data Evaluation, Land Cover Classification, and Land-based Carbon Inventories and Baseline Projection Methodology Memorandum

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May 17, 2022
Amended: June 2023
Project No: 21-11493

Jody London, Sustainability Coordinator
Contra Costa County
255 Glacier Drive
Martinez, California 94553
Via email: Jody.London@dcd.cccounty.us

Subject: Contra Costa County Data Evaluation, Land Cover Classification, and Land-based Carbon Inventories and Baseline Projection Methodology Memorandum

Dear Ms. London:

Rincon Consultants, Inc. (Rincon) has completed the data gathering and data evaluation phase of the draft land classification for Contra Costa County (County) and has summarized the results of this phase in this memorandum to provide transparency about the data collected as well as next steps. Data was gathered from State and National land cover databases and reviewed with the project team, including County staff, Contra Costa Resource Conservation District staff, and University of California Cooperative Extension staff. Rincon completed a land cover classification analysis through an internally and externally vetted quality assurance/quality control (QA/QC) process. This data will then be used to develop the land-based carbon inventories based on methodology presented in Resilient Merced, [1] California's 2017 Climate Change Scoping Plan, [2] and California's 2018 Natural and Working Lands Inventory.[3] These sources identify principles to guide the quantification of carbon stored in, and emitted from, natural and working lands in a complete, accurate, consistent, and transparent manner. This memorandum includes the following:

- **Background**
  - Why Evaluate Carbon Stored in Natural and Working Lands
  - How to Inventory Carbon Stored in Natural and Working Lands
  - Contra Costa Land Cover Characteristics
- **Data Evaluation**
  - **Data Sources Used.** A complete description of the data sources used to complete the land classification analysis underlying the carbon inventories and baseline reference projection

[1] California Department of Conservation, The Nature Conservancy, Tukman Geospatial, Climate Action Reserve, and Merced County. 2018. Resilient Merced. Available: https://maps.conservation.ca.gov/TerraCount/downloads/. Accessed March 11, 2022.
[2] California Air Resources Board (CARB). 2017. California's 2017 Climate Change Scoping Plan. Available: <https://ww2.arb.ca.gov/sites/default/files/classic//cc/scopingplan/scoping_plan_2017.pdf>. Accessed March 11, 2022.
[3] CARB. 2018. An Inventory of Ecosystem Carbon in California's Natural and Working Lands. Available: <https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf>. Accessed March 11, 2022.

- **Quality Assurance and Quality Control (QA/QC).** An overview of the County specific data refinements and corrections made as a result of data quality assessment and quality control measures used in the land classification analysis
- **Land Cover Classification Methodology and Results.** Methods and results related to the land cover classification process for 2001 and 2021

- **Next Steps**
  - Land-based Carbon Inventories and Baseline Projection Methodology
    - **Carbon Inventories.** Proposed methods related to development of carbon stock estimates for 2001 and 2021
    - **Baseline Projection.** Proposed methods related to the establishment of the baseline reference projection, or baseline projection

- **Conclusion.** Rincon's overall data assessment and summary of next steps

The work completed so far and summarized in this memorandum is illustrated in the graphic below. Upon review of this memorandum and approval from the County, Rincon will complete and provide the Land-based Carbon Inventories and Baseline Projection to the County for review.

Background

Why Evaluate Carbon Stored in Natural and Working Lands

Up until recently, natural and working lands have not been a critical part of local climate action planning efforts across the State. However, both greenhouse gas (GHG) emissions reductions and carbon sequestration play an important role in the State's ability to achieve its carbon neutrality goal established by Executive Order B-55-18.[4] Therefore, to meet this ambitious goal, jurisdictions across California will need to increase efforts to conserve, restore, and manage forests, rangelands, farms, urban green spaces, wetlands, and soils. Efforts to conserve, restore, and manage natural and working lands effectively require understanding the current land-based carbon stock and carbon sequestration potential of land management activities on these lands. This understanding of the current baseline will

[4] State of California Executive Department. 2018. Executive Order B-55-18 to Achieve Carbon Neutrality. Available: https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf . Accessed March 11, 2022.

allow for future verification of carbon sequestration and GHG emission reduction projects. The land-based carbon stock is the total amount of carbon sequestered in woody and herbaceous material and in the soil. The purpose of this memorandum is to provide Contra Costa County with an overview of the data and methodology to be used for the current (2021) and historical (2001) land-based carbon inventories.

How to Inventory Carbon Stored in Natural and Working Lands

Resilient Merced, which resulted from a collaboration between Merced County, The Nature Conservancy, and the California Department of Conservation, outlines the methodology used in Merced County to inventory and project carbon stored in natural and working lands. The Contra Costa County carbon inventories and baseline reference projection will follow the methodology outlined in Resilient Merced, California's 2017 Climate Change Scoping Plan, and the State's Natural and Working Lands Inventory.[5,6,7] A land-based carbon inventory is a quantitative estimate of the existing state of carbon stored in the land. Land-based inventories provide estimates of carbon stocks, stock-changes, and resulting GHG sequestered or emitted from different stock changes. Land-based emissions exist in the form of methane and nitrous oxide, which are associated with wetlands and agricultural practices such as fertilizer application. Emissions from agricultural practices will not be included in the Contra Costa County carbon inventories since these are included in the County's Community GHG Emissions Inventory.[8] Including these emissions in the land-based carbon inventories would result in double counting emissions. The agricultural emissions included in the County's Community GHG Emissions Inventory include:

- Fertilizer use for crops
- Fuel use for agricultural equipment
- Activities associated with raising livestock

However, emissions from wetlands were not included in the Community GHG Emissions Inventory and will therefore be calculated as part of the land-based carbon inventory.

The carbon inventories will estimate carbon stocks by land-cover class (e.g., forest, grassland, shrub, etc.) at two points in time (2001 and 2021) to determine historical changes and calculate future trends in carbon stocks. Trends derived from the carbon inventories will establish the baseline reference projection, or baseline projection, for Contra Costa County. The baseline projection represents the business-as-usual (BAU) condition for the land cover types in the county. Thus, it can be used as a benchmark against which management activities designed to increase carbon stocks can be assessed.

Contra Costa Land Cover Characteristics

Contra Costa County stretches over approximately 516,185 acres of land, which includes all natural, agricultural, and urban areas, both incorporated and unincorporated. In the west and central county,

[5] California Department of Conservation, The Nature Conservancy, Tukman Geospatial, Climate Action Reserve, and Merced County. 2018. Resilient Merced. Available: https://maps.conservation.ca.gov/TerraCount/downloads/. Accessed March 11, 2022.

[6] California Air Resources Board (CARB). 2017. California's 2017 Climate Change Scoping Plan. Available: <https://ww2.arb.ca.gov/sites/default/files/classic//cc/scopingplan/scoping_plan_2017.pdf>. Accessed March 11, 2022.

[7] CARB. 2018. An Inventory of Ecosystem Carbon in California's Natural and Working Lands. Available: <https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf>. Accessed March 11, 2022.

[8] Contra Costa County. 2019. Greenhouse Gas Emissions Inventory. Available: < https://envisioncontracosta2040.org/wp-content/uploads/2019/04/Sustainability-Commission-04-22-19-CAP-Memo.pdf>. Accessed March 11, 2022.

the primary land uses in suburban cities and towns are residential, commercial, and industrial. In the east county, land has primarily been used for agriculture and general open space. Over time, development pressure has steadily moved eastward from the communities bordering the bay in the west to the valleys near Mount Diablo, and eventually to the communities in the east county subarea. Much of the workforce in Contra Costa commutes from the communities found in elongated corridors along a network of major transportation routes to the employment centers in San Francisco and Alameda Counties. As of 1990, approximately 25 percent of the county was devoted to urban uses, while the remainder was dedicated to non-urban uses such as agriculture, wetlands, parks, recreation, and general open space. Non-urban uses also include rural residential and agricultural structures, and facilities for public purposes.

Contra Costa County's current General Plan was adopted in 1991 and has been reconsolidated twice, once for 1990-2005 and again for 2005-2020. A comprehensive General Plan update, "Envision Contra Costa 2040," is currently underway and is expected to be completed in 2022. The updated General Plan will address sustainability, environmental justice, and affordable housing, among other things, while continuing to balance growth and conservation.

Envision Contra Costa 2040 will update all General Plan elements including three that relate directly to the natural and working lands of the unincorporated county. The Land Use Element identifies land use designations for the unincorporated county. Integral to this Element are the Urban Limit Line (ULL), and the 65/35 Land Preservation Standard. The ULL was originally established by county voters through the adoption of Measure C-1990. The ULL establishes a line beyond which no urban land uses can be designated during the term of the County General Plan to ensure preservation of identified non-urban agricultural, open space, and other areas, and facilitates enforcement of the 65/35 Standard. Additionally, the General Plan includes a Conservation Element, which addresses natural resources in unincorporated County land, including air, water, soil, and habitat; and the Open Space Element that establishes policies and implementation for preservation of open space lands categorized as scenic resources, historic resources, and park and recreational facilities.

Data Evaluation

The State's Natural and Working Lands Inventory indicates that data used to develop carbon inventories should be accurate, consistent, and available for past and present years and into the future. Jurisdictional carbon inventories require the use of large-scale spatial data sets and carbon or biomass data. Geographic information system (GIS) is used to capture, store, manipulate, analyze, manage, and present spatial, or geographic, data across the county. Baseline reference trends use historic and current datasets, and future data can be used to monitor progress or impacts from implemented management activities. The Contra Costa County carbon inventories will use publicly available data sources that are expected to be updated in the future. Table 1 includes the data sources used to complete the Contra Costa County 2001 and 2021 land cover analysis that will be the basis for the countywide carbon inventories and baseline projection. The data sources are described in more detail following the table.

Table 1 Data Sources Used

Land Type	Data Name and Developing Agencies	Publication Frequency	Year
Natural Lands (Forest, Shrubland, Grassland, etc.), and Agricultural Lands (Pasture and Hay, Orchards, Cultivated Crops, and Vineyards)	LANDFIRE[1] developed, in part, by the United States Department of Agriculture (USDA) Forest Service and the United States Department of the Interior.	2 years	2001, 2021
	Multi-Resolution Land Characteristics Consortium (MRLC) – National Land-cover Database (NLCD)[2] developed by a group of federal agencies. Partners include the United States Bureau of Land Management, National Agricultural Statistics Service (NASS), National Oceanic and Atmospheric Administration (NOAA), USDA Forest Service and the United States Geological Survey.	5 years	2001, 2021
Urban Forest	i-Tree Canopy (v7.1)[3] developed, in part, by the USDA Forest Service.	Annual	2021
Soil	NCSS Characterization Database, the National Soil Information System (NASIS), and the Rapid Carbon Assessment (RaCA) datasets[4] developed, in part, by the National Soil Survey Center (NSSSC), Kellogg Soil Survey Laboratory (KSSL), USDA, and National Resource Conservation Service (NRCS).	N/A[5]	2017

[1] LANDFIRE data - https://www.landfire.gov/

[2] NLCD data - https://www.mrlc.gov/data?f%5B0%5D=category%3ALand%20Cover

[3] i-Tree Canopy Tool - https://canopy.itreetools.org/

[4] Soil data - https://scholarsphere.psu.edu/resources/ea4b6c45-9eba-4b89-aba6-ff7246880fb1

Ramcharan A.,Hengl T., Nauman T., Brungard C., Waltman S., Wills S., Thompson J. (2017) Soil Property and Class Maps of the Conterminous US at 100 meter Spatial Resolution based on a Compilation of National Soil Point Observations and Machine Learning. Submitted to Soil Science Society of America Journal.

[5] Currently a snapshot in time for 2017 – future updates not planned.

Natural Lands: LANDFIRE and National Land Cover Database (NLCD)

LANDFIRE spatial land-cover data provides the foundation of the Contra Costa County land cover analysis that will underlie the County's carbon inventories, similar to the Resilient Merced project completed for Merced County and the State's Natural and Working Lands Carbon Inventory developed for the California Air Resources Board (CARB).[9] The data sources used to develop the land cover analysis are described below and illustrated in Figure 1.

LANDFIRE (Landscape Fire and Resource Management Planning Tools) is a shared program between the wildland fire management programs of the U.S. Department of Agriculture Forest Service and U.S. Department of the Interior, providing landscape scale geo-spatial products to support cross-boundary planning, management, and operations. LANDFIRE vegetation data includes Existing Vegetation Type (EVT), Existing Vegetation Canopy Cover (EVC), and Existing Vegetation Height (EVH). These layers are created using predictive landscape models based on extensive field-referenced data, satellite imagery and biophysical gradient layers using classification and regression trees. LANDFIRE geo-spatial products are delivered as 30-meter pixels; however, they should not be used at the individual pixel level or on small groups of pixels. LANDFIRE products are best used when interpretation or analysis is needed at a landscape scale rather for a particular locality. Appropriate landscape-scale analysis may include nationwide, regional (single large states, groups of smaller states), or sub-regional (large landscapes) strategic planning. LANDFIRE products are designed to be used to support resource management

[9] California Department of Conservation, The Nature Conservancy, Tukman Geospatial, Climate Action Reserve, and Merced County. 2018. Resilient Merced. Available: https://maps.conservation.ca.gov/TerraCount/downloads/. Accessed March 11, 2022.

initiatives related to vegetation, fire management planning, stewardship of public and private lands, climate change and carbon sequestration and other topics.

The LANDFIRE data covers the county at a 30-meter resolution. The LANDFIRE layers used for the analysis include Existing Vegetation Type, Cover, and Height. Identified inaccuracies in shrubland classification were found in the LANDFIRE dataset for Contra Costa, for example, grassland/herbaceous areas were categorized as shrub/scrub. Given these discrepancies, the National Land-cover Database (NLCD), which was determined to accurately categorize shrubland and grassland in the county, and desktop ground truthing was used to supplement the LANDFIRE data.

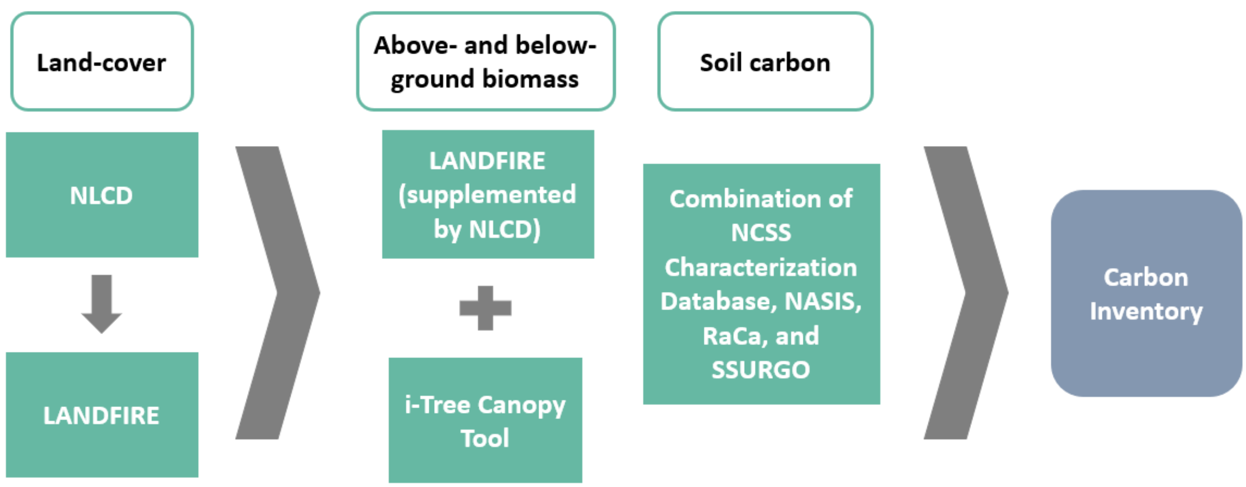
Urban Forest: i-Tree Canopy

Urban forest density estimates were calculated using the i-Tree Canopy tool. This tool estimates percent tree cover with a random sampling process and aerial imagery. Percent tree cover in urban areas of the county is estimated to be about 21 percent. This percentage will be used to estimate carbon stored in urban areas of the county.

Soil: NCSS, NASIS, RaCA and SSURGO

Soil data used includes three national United States soil point datasets: NCSS Characterization Database, the National Soil Information System (NASIS), and the Rapid Carbon Assessment (RaCA) datasets. These datasets include remote sensing images, predictions of soil properties (e.g., percent organic carbon, total nitrogen, bulk density, PH) and classes, conventional soil polygon maps from the Soil Survey Geographic database (SSURGO), and machine learning.

Figure 1 Data to be Used for the Contra Costa County Inventories (2001 and 2021)



Quality Assurance and Quality Control (QA/QC)

Given the importance of the underlying data in driving the results of the carbon inventories, Rincon consultants undertook quality assurance and quality control measures. Data availability and quality were assessed throughout the collection and land classification analysis process through input from stakeholders, spatial analysis and desktop ground truthing. Data errors were addressed as outlined below.

While the data and tools used were the best available at the time of this study, there may be new local-scale data products available for future analyses that would further refine the results and allow for more tailored land management recommendations. For example, CALFIRE and the East Bay Regional Parks District are currently undertaking a Landscape and Fuels Mapping Project for Alameda and Contra Costa Counties that will produce new datasets that have a resolution of 1-meter for canopy density and height, and 20-meter for ladder fuels. These are finer resolutions than the 30 by 30-meter areas used for this study.

Agricultural Land Classification

The following four data sources were reviewed for agricultural land classification:

1. LANDFIRE
2. USDA Cropland Data Layer[10]
3. Census of Agriculture[11]
4. County Crop Reports

Data Source Methodology

1. **LANDFIRE[12].** LANDFIRE existing vegetation layers describe the following elements: Existing Vegetation Type (EVT), Existing Vegetation Canopy Cover (EVC), and Existing Vegetation Height (EVH). These layers are created using predictive landscape models based on extensive field-referenced data, satellite imagery and biophysical gradient layers using classification and regression trees.

   LANDFIRE's Existing Vegetation Type (EVT) represents the current distribution of the terrestrial ecological systems classification, developed by NatureServe for the western hemisphere. A terrestrial ecological system is defined as a group of plant community types (associations) that tend to co-occur within landscapes with similar ecological processes, substrates, and/or environmental gradients. The LANDFIRE Ecological Systems Descriptions for the contiguous United States (CONUS) provides descriptions for each Ecological System including species, distribution and classification information. EVT also includes ruderal or semi-natural vegetation types within the U.S. National Vegetation Classification (NVC). The LANDFIRE Ruderal NVC Groups Descriptions for CONUS provides descriptions for each ruderal NVC Group including species, distribution, and classification information. EVT is mapped using decision tree models, field data, Landsat imagery, elevation, and biophysical gradient data. Decision tree models are developed separately for each of the three lifeforms—tree, shrub, and herbaceous and are then used to generate lifeform specific EVT layers. Disturbance products are included in LANDFIRE 2016 Remap products to describe areas on the landscape that have experienced change within the previous 10-year period. The EVT product is reconciled through QA/QC measures to ensure life-form is synchronized with both Existing Vegetation Cover and Existing Vegetation Height.

   LANDFIRE's Existing Vegetation Cover (EVC) represents the vertically projected percent cover of the live canopy layer for a 30-m cell. EVC is generated separately for tree, shrub, and herbaceous cover

[10] USDA Cropland Data Layer. 2021. Cropscape. Available: < https://nassgeodata.gmu.edu/CropScape/>. Accessed March 1, 2022.
[11] USDA Census of Agriculture. 2019. Census of Agriculture Historical Archive. Available: <https://agcensus.library.cornell.edu/census_parts/2002-california/>. Accessed March1, 2022.
[12] LANDFIRE Data Products - Vegetation. LANDFIRE. Available: < https://landfire.gov/vegetation.php >. Accessed March 17, 2022.

lifeforms using training data and other geospatial layers. Percentage tree, shrub, and herbaceous canopy cover training data are generated using plot-level ground-based visual assessments and Lidar observations. Once the training data are developed, relationships are then established separately for each lifeform between the training data and combination of Landsat and ancillary data. Each of the derived data layers (tree, shrub, herbaceous) has a potential range from 0-100 percent and are merged into a single composite EVC layer. Disturbance data were used to develop LANDFIRE 2016 Remap products for LANDFIRE Reference Database plot filtering and to ensure inclusion of 2015 and 2016 disturbances that were not visible in the source imagery. The EVC product is then reconciled through QA/QC measures to ensure life-form is synchronized with both Existing Vegetation Height and Existing Vegetation Type products.

2. **USDA Cropland Data Layer[13].** The Cropland Data Layer (CDL) provides a raster, geo-referenced, crop-specific land cover map for the continental United States. The CDL also includes a crop mask layer and planting frequency layers, as well as boundary, water and road layers. The data are created annually using moderate resolution satellite imagery and extensive agricultural ground truth. The pre-2006 CDLs relied primarily on satellite imagery from the Landsat TM/ETM satellites, which had a 16-day revisit. The only source of ground truth was the NASS June Area Survey (JAS). Starting in 2006, NASS began utilizing a new satellite sensor, new commercial off-the-shelf software, and more extensive training/validation data. The in-house software was phased out in favor of a commercial software suite, which includes Erdas Imagine, ESRI ArcGIS, and Rulequest See5. This allowed for unlimited satellite imagery and ancillary dataset inputs. The new source of agricultural training and validation data became the USDA Farm Service Agency (FSA) Common Land Unit (CLU) Program data, which was much more extensive in coverage than the JAS and was in a GIS-ready format. NASS also began using the most current USGS National Land Cover Dataset (NLCD) dataset to train over the non-agricultural domain. The new classification method uses a decision tree classifier. The CDL first included California in 2007, with coverage for the entire continental US beginning in 2008. The 2021 CDL product was released February 14, 2022. The 2021 CDL product utilized satellite imagery from the Landsat 8 OLI/TIRS sensor, the ISRO ResourceSat-2 LISS-3, and the ESA SENTINEL-2 sensors collected during the current growing season. Imagery is downloaded daily throughout the growing season with the objective of obtaining at least one cloud-free usable image every two weeks throughout the growing season. The spatial resolution is 30 meters covering the Continental United States. There were no new CDL categories added in 2021.
3. **Census of Agriculture[14].** The Census of Agriculture aims to account for "any place from which $1,000 or more of agricultural products were produced and sold, or normally would have been sold, during the census year." To do this, the National Agricultural Statistics Service (NASS) maintains a list of farmers and ranchers and from this list creates a Census Mail List (CML) of agricultural operations that potentially meet the farm definition. NASS uses its June Area Survey (JAS) to quantify the number and types of farms not on the CML. The records in the JAS that are not on the CML are said to be in the Noton-the-Mail List (NML) domain. If a JAS record in the NML domain is determined to be a farm during the census, it is an NML farm. The NML farms are used to measure coverage associated with the census. Agricultural information is then collected from the agricultural operations. Data collection is accomplished primarily by mail, Computer-Assisted Self Interview

[13] CropScape and Cropland Data Layers – FAQs. 2021. USDA NASS. Available: https://www.nass.usda.gov/Research_and_Science/Cropland/sarsfaqs2.php#Section3_2.0. Accessed March 17, 2022.
[14] Appendix A: Census of Agriculture Methodology. 2017. USDA Census of Agriculture. Available: caappxa.pdf (usda.gov). Accessed March 17, 2022.

(CASI) on the Internet, and personal enumeration for special classes of records in the census operations. Data is reviewed by both computer and analysts with the Census Editing Unit and appropriate corrects or imputations are made to ensure consistency across the data set. Data is combined to provide summary information on the characteristics of farm operations and farm producers at the national, State, and county levels.

4. **County Crop Reports[15].** The County Crop Report methodology has remained the same for over 20 years, allowing for comparisons across years. The Contra Costa Department of Agriculture conducts headquarter inspections with growers for pesticide use. The small number of growers that do not have a permit with the department are on a call or visit list. Growers are seen each year and are asked to fill out a spreadsheet with crops grown and acreage; changes in crops and acreage are reported at this time along with any divergence from their permit. The County then compiles all grower data and derives average yield, value, and other summary metrics. For the few growers unable to be contacted for annual data collection, acreage and crop types are based on the associated grower permit and inspector records. After data compilation, the County is required by law to destroy all the individual grower information, as well as anything that can be used to derive an individual's financial information. Cattle ranchers do not have permits with the County but are sent mailers requesting data annually. Some key ranchers, as well as the Cattlemen's Association, sometimes provide data; however, due to higher variability in data collection year to year, cattle ranching land use estimates have a lower precision level compared to the other agricultural metrics compiled by the County.

Both the LANDFIRE and USDA Cropland Data Layer spatial datasets are updated regularly. LANDFIRE is updated every two years and USDA Cropland Data Layer is updated annually. The earliest data set available from the USDA Cropland Data Layer for Contra Costa County is 2007, which does not align with the baseline inventory year of 2001. The County Crop Reports and Census of Agriculture data do not provide spatial information. County Crop reports are likely to be the most accurate crop dataset providing acreages for different agricultural land uses since they are locally developed by reviewing permits and speaking to growers and ranchers in the county. The section below provides a comparison of the agricultural land classification datasets reviewed and explains which spatial dataset was best aligned with the County Crop Report.

Data Source Results Comparison

Rincon reviewed the agricultural acres for 2021 from the data sources described above (LANDFIRE, USDA Cropland Data Layer, County Crop Reports, Census of Agriculture). Census of Agriculture data was deemed not useful for this analysis because of the large discrepancies in the Pasture and Hay and Cultivated and Field Crop categories (see Table 2), likely due to different categorization of agricultural lands. In addition, Census of Agriculture data is not spatial, and therefore cannot be used in the County's land classification analysis. As shown in Table 2 and Figure 2, LANDFIRE agricultural acres were better aligned with the County Crop Reports than USDA Cropland Data Layer agricultural acres, and therefore, LANDFIRE was selected as the best available spatial data for agricultural land cover classes. Although LANDFIRE and the County Crop Reports are not identical, inaccuracies are expected in satellite-based land cover classification and the discrepancies found between LANDFIRE and the County Crop Reports will not have a major impact on the jurisdiction-wide land-based carbon inventories.

[15] A description of the County's methodology for generating County Crop Reports was provided by Matt Slattengren, Agricultural Commissioner/Sealer of Weights and Measures, Contra Costa County Department of Agriculture on March 11, 2022.

Table 2 Agricultural Acres by Data Source

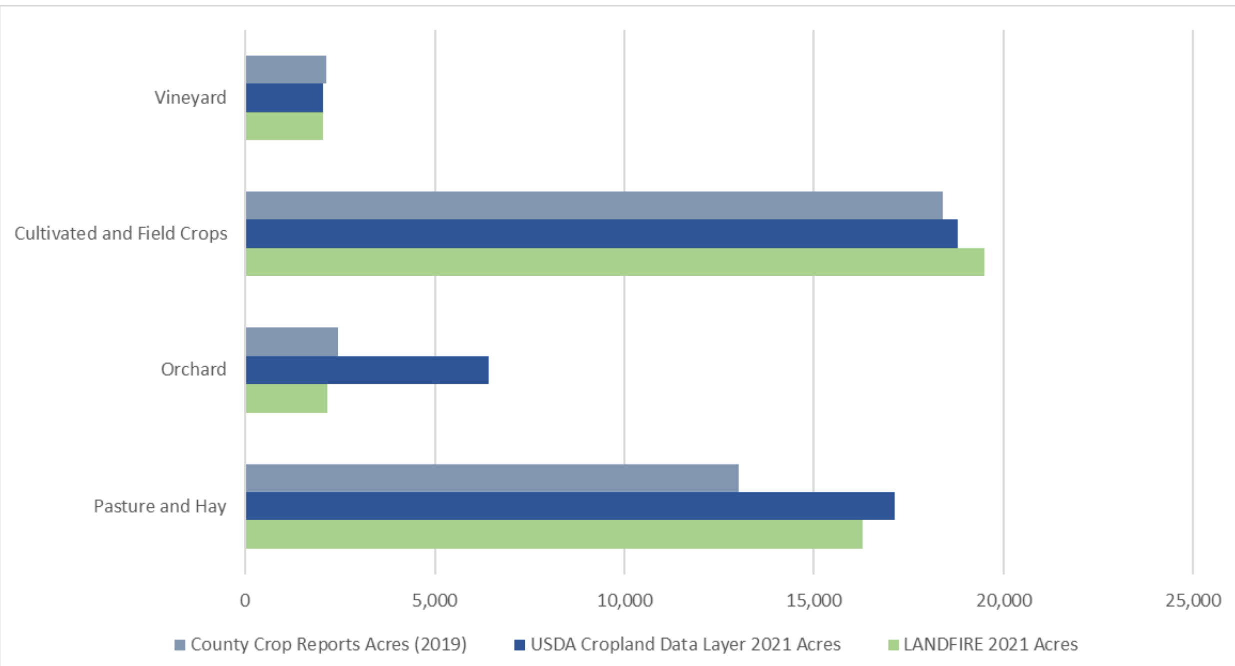
Land-cover Class	LANDFIRE 2021 Acres	USDA Cropland Data Layer 2021 Acres	County Crop Reports Acres (2019)[1]	Census of Agriculture Data (2017)[2]
Pasture and Hay	16,284	17,138	13,011	6,381
Orchard	2,175	6,411	2,438	4,792
Cultivated and Field Crops (includes cultivated crops and irrigated agriculture, close grown crops, and row crops)	19,492	18,781	18,397	30,142[3]
Vineyard	2,060	2,048	2,136	1,775
Total	**40,011**	**44,378**	**35,982**	**43,090**

[1] 2019 is the latest year available for County Crop Reports

[2] 2017 is the latest year available for Census of Agriculture Data

[3] Census of Agriculture calls this category "Harvested Cropland," this dataset is not useful for this analysis given the large discrepancy in the Pasture and Hay and Cultivated and Field Crop categories – likely a categorization discrepancy with the other data sources.

Figure 2 Agricultural Acres by Data Source



LANDFIRE Inaccuracies

LANDFIRE was determined to be appropriate for use in this landscape-level regional analysis. Over 2 million 30-meter pixels made up the area analyzed for Contra Costa County for each 2001 and 2021. Roughly 99 thousand pixels were reviewed in the QA/QC process by the GIS team and input was also solicited from stakeholders. During the QA/QC process inaccuracies were identified in LANDFIRE's classification of grassland/herbaceous land cover, therefore, NLCD and satellite imagery was used to identify potentially misclassified areas. Shrub/scrub and grassland/herbaceous cells with mismatched LANDFIRE and NLCD categories were reclassified to the values of the nearest LANDFIRE cell of that type within 2,000 feet. For example, if a cell has a LANDFIRE classification of grassland/herbaceous in 2001 but an NLCD classification of shrub/scrub in 2001, that cell would be reclassified to shrub/scrub if there was another LANDFIRE shrub/scrub cell within 2,000 feet. The nearest LANDFIRE cell is used to update the data because LANDFIRE provides information needed for carbon stock calculations, including vegetation type, height and cover, whereas NLCD only provides vegetation type. Of the pixels reviewed during QA/QC, over 21 thousand pixels were reclassified to correct the land cover class. Examples of the LANDFIRE discrepancies are depicted in Figure 3, below.

Stakeholder review of the land cover classification identified additional areas, mainly pasture and hay, barren, and wetlands that were incorrectly classified.[16] The areas identified were cross-checked with satellite imagery and updated to reflect the appropriate land cover type.

Land Cover Classification Methodology and Results

The land cover classification follows the methodology outlined in Resilient Merced and the State's Natural and Working Lands Inventory.[17,18,19] The methodology and results of the land cover classification are presented below.

Land Cover Classification

This analysis was conducted using 30-meter cell resolution across the county for 2001 and 2021. The carbon inventories will be derived from the assignment of all land in the county comprised of discrete land-cover classes. The Existing Vegetation Type LANDFIRE and NLCD datasets were used to determine the land-cover classes. The land-cover classes assigned in the 2001 and 2021 inventories are:

- Barren – areas where vegetation accounts for less than 15 percent of total cover, for example areas of bedrock, sand dunes, or gravel pits.
- Cultivated and Field Crops – areas used for the production of vegetables and field crops generally grown for human consumption, such as corn, soybeans, and wheat.
- Development – areas with constructed materials, including buildings and roads.
- Forest – areas dominated by trees with more than 10 percent tree cover.[20]
- Grassland/Herbaceous – areas dominated by herbaceous vegetation, with more than 10 percent herb cover, less than 10 percent tree cover and less than 10 percent shrub cover.
- Open Water – areas of water with less than 25 percent cover of vegetation or soil.
- Orchard – areas used for the production of fruits and nuts.
- Pasture and Hay – areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture or hay accounts for more than 20 percent of total vegetation.

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[16] Misclassified areas identified by Abigail Fateman, Executive Director of East Contra Costa County Habitat Conservancy, Kamyar Aram, Specialty Crops Advisor with University of California Cooperative Extension, and Ben Weise, Agriculture Conservation Manager with Contra Costa Resource Conservation District (April 2022).

[17] California Department of Conservation, The Nature Conservancy, Tukman Geospatial, Climate Action Reserve, and Merced County. 2018. Resilient Merced. Available: https://maps.conservation.ca.gov/TerraCount/downloads/. Accessed March 11, 2022.

[18] California Air Resources Board (CARB). 2017. California's 2017 Climate Change Scoping Plan. Available: <https://ww2.arb.ca.gov/sites/default/files/classic//cc/scopingplan/scoping_plan_2017.pdf Accessed March 11, 2022.

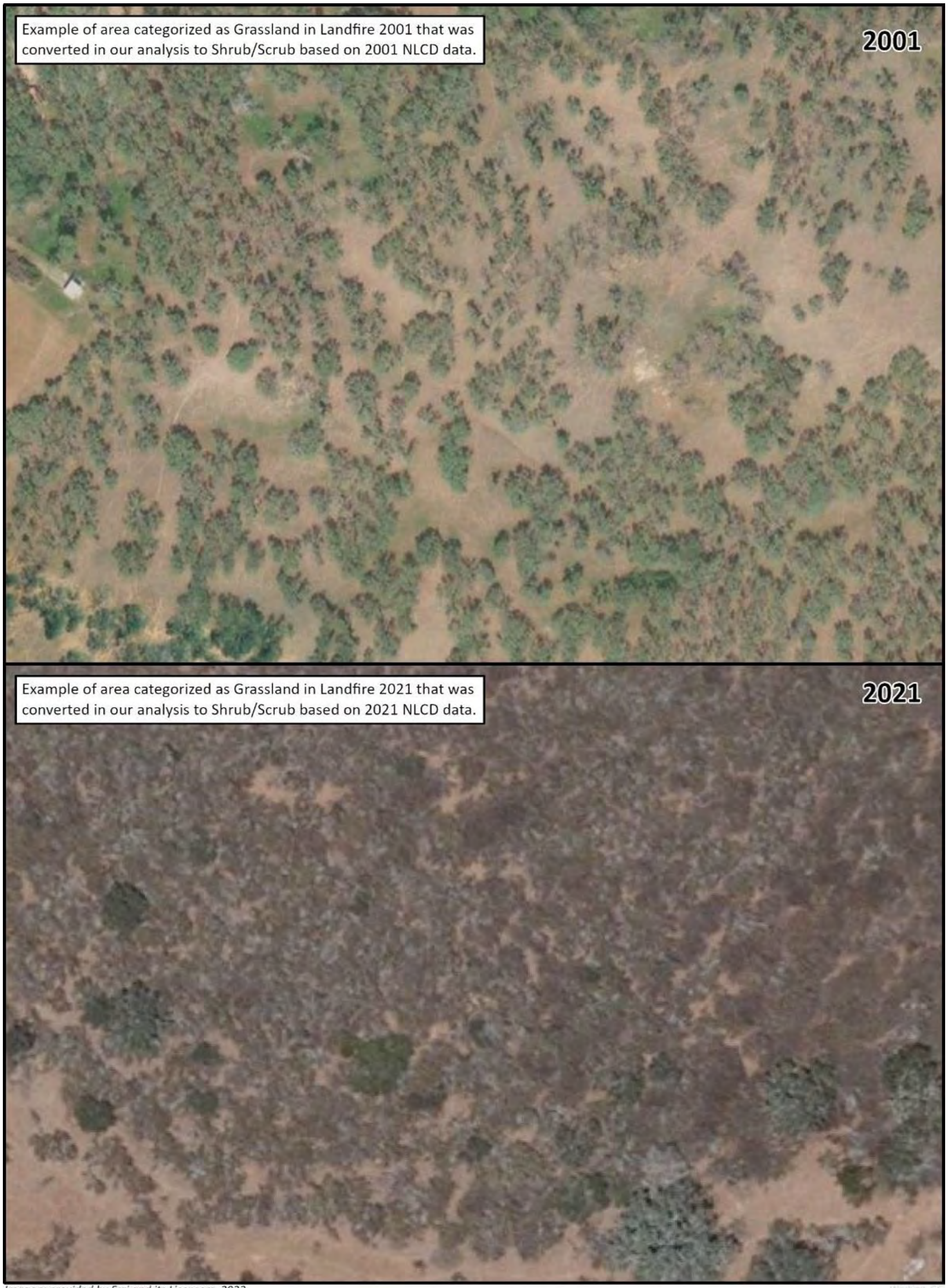
[19] CARB. 2018. An Inventory of Ecosystem Carbon in California's Natural and Working Lands. Available: <https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf>. Accessed March 11, 2022.

[20] Includes riparian areas that are dominated by trees with more than 10 percent tree cover.

- Shrub/Scrub – areas dominated by shrubs greater than 10 percent of total shrub cover and less than 10 percent tree cover.[21]
- Vineyard – areas planted with grapevines, generally used for producing grapes used in winemaking.

[21] Includes riparian areas that are dominated by shrubs greater than 10 percent of total shrub cover and less than 10 percent tree cover.

Figure 3 LANDFIRE Inaccuracies (2001 and 2021)



Imagery provided by Esri and its Licensors, 2022.

- Wetland – areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the perennial herbaceous vegetation indicate soil or substrate periodically saturated with or covered with water.

See the Quality Assurance and Quality Control (QA/QC) section for a detailed description of how LANDFIRE classification inaccuracies were identified and resolved.

Land Cover Classification Results are summarized in Figure 4, Figure 5, Figure 6, Figure 7, Figure 8, and Table 3 below. Between 2001 and 2021 the largest losses in acreage occurred in shrubland and cultivated and field crops. The largest increase in acreage between 2001 and 2021 was in development. As shown in Figure 5, much of the development occurred on former agricultural land (cultivated cropland and pasture and hay) and shrubland indicating a trend of extensive development converting natural and working lands to housing, commercial and other developed uses.

The data show that between 2001 and 2021, developed land cover increased by 48% and totaled an estimated 40,921 acres in 2021. During the same period, the area classified as shrubland decreased by 51%, a loss of an estimated 35,052 acres. As is observable in the above land classification maps, much of the development occurred on former cultivated cropland, pasture and hay, and shrubland indicating a trend of extensive development converting natural and working lands to housing, commercial and other developed uses. The third most substantial change in land cover by acreage after development and shrub land, is the 11,012-acre decrease in cultivated and field crops. This reduction represents a 29% decrease between the two reference years (2001 and 2021). The data show large percent change increases in the land classified as vineyards (503% increase) and orchards (166% increase); however, these are two of the smallest land uses in the County, accounting for less than 1% of total County acreage. These large increases are likely caused by changes in LANDFIRE land classification between the two inventory years, for example, orchard and vineyard areas being classified as cultivated and field crops in 2001. However, some of the decrease in cultivated and field crop land may be attributed to switching of land from one agricultural use to another because when all agricultural land cover classifications (cultivated and field crops, orchard, pasture and hay, vineyard) are summed for both 2001 and 2021, there is an overall decrease in land classified under agricultural land cover types. In 2001 there was a total of 55,856 acres of land classified under agricultural uses and by 2021 that decreased by 22% (12,127 acres) to 43,729 acres classified under agricultural uses. This indicates an overall trend of loss of agricultural lands to other uses.

Figure 4 Land Cover Maps (2001 and 2021)

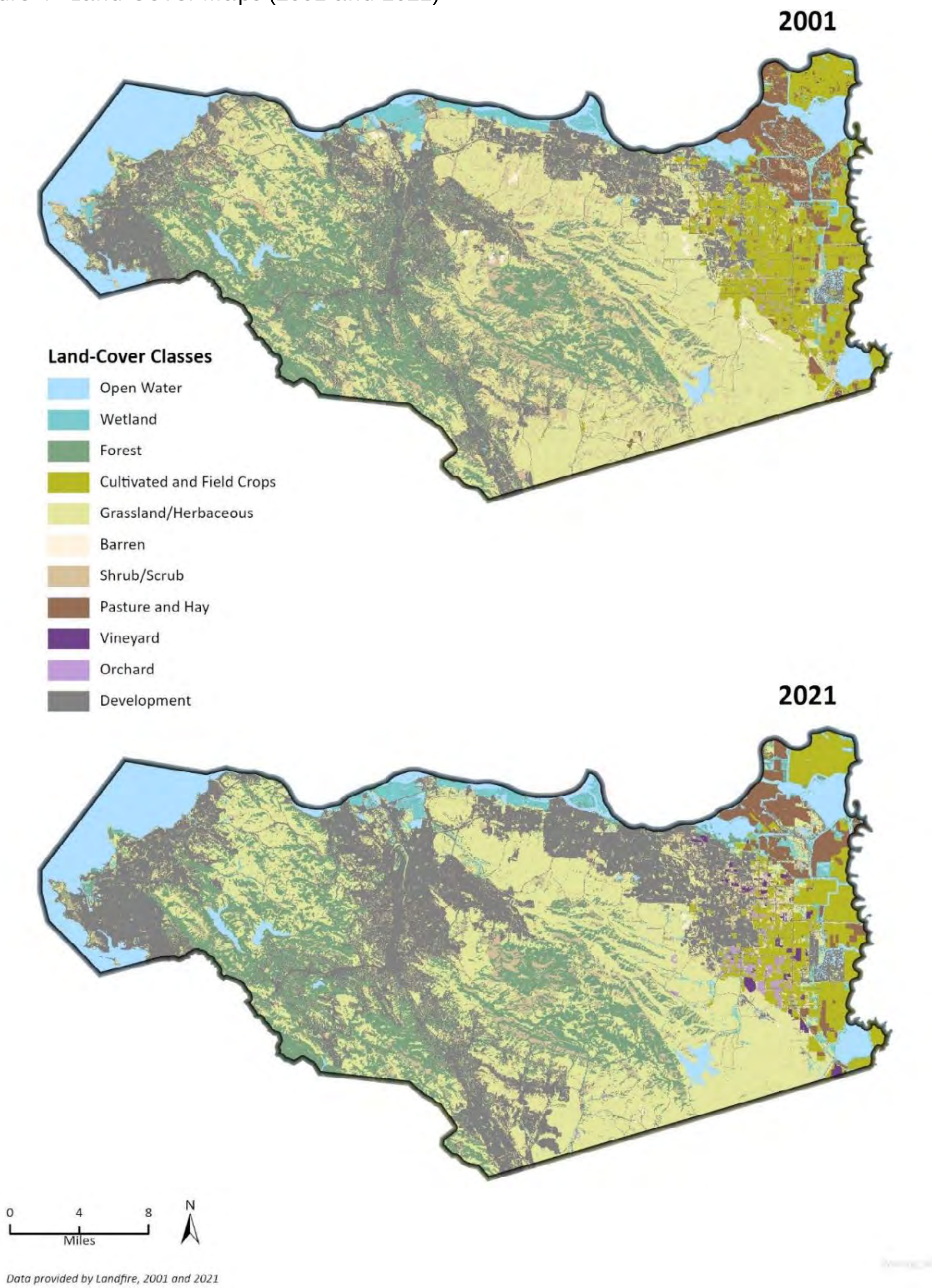


Figure 5 Urban Expansion

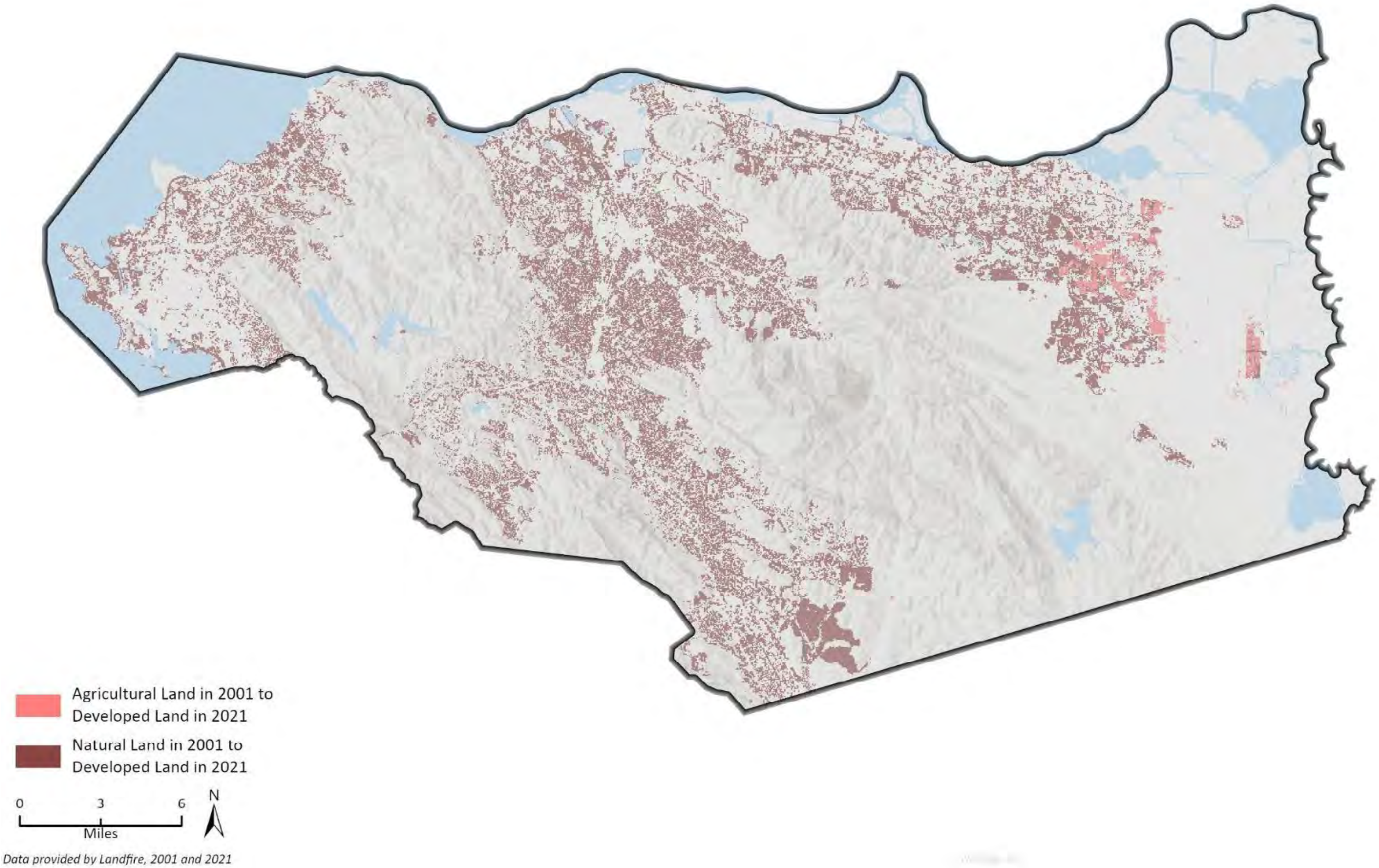


Figure 6 2001 Land Cover

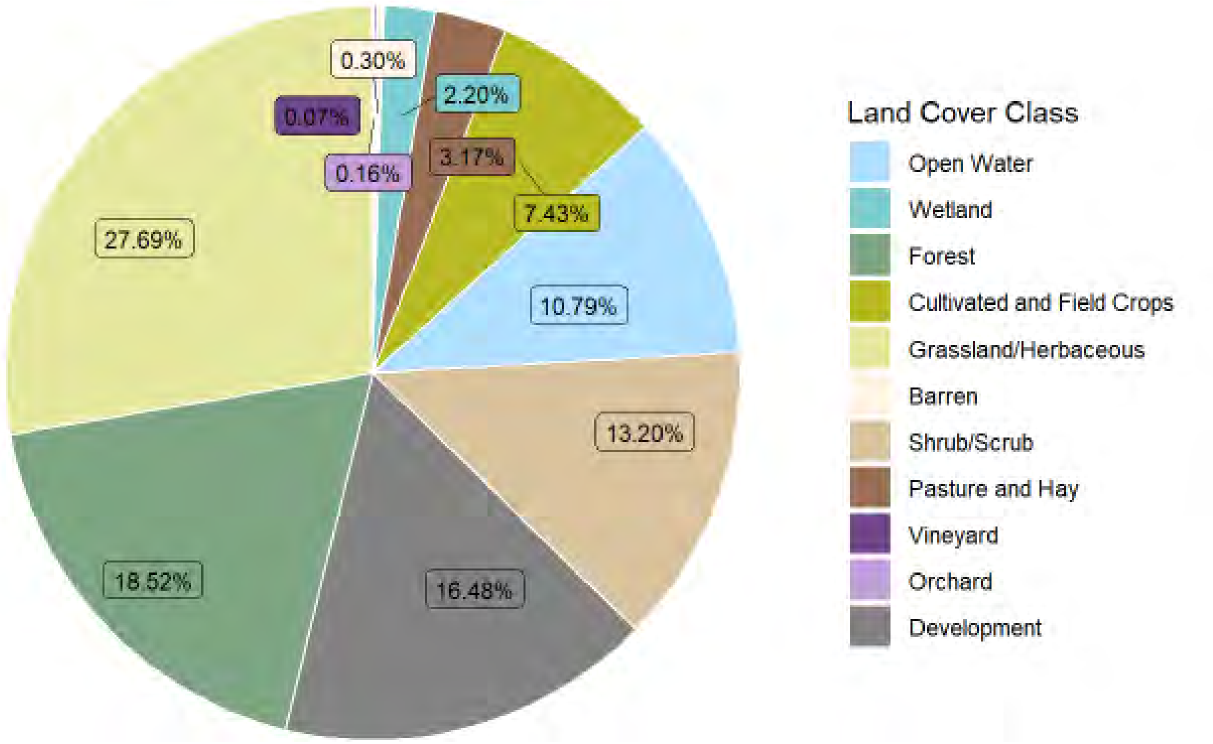


Figure 7 2021 Land Cover

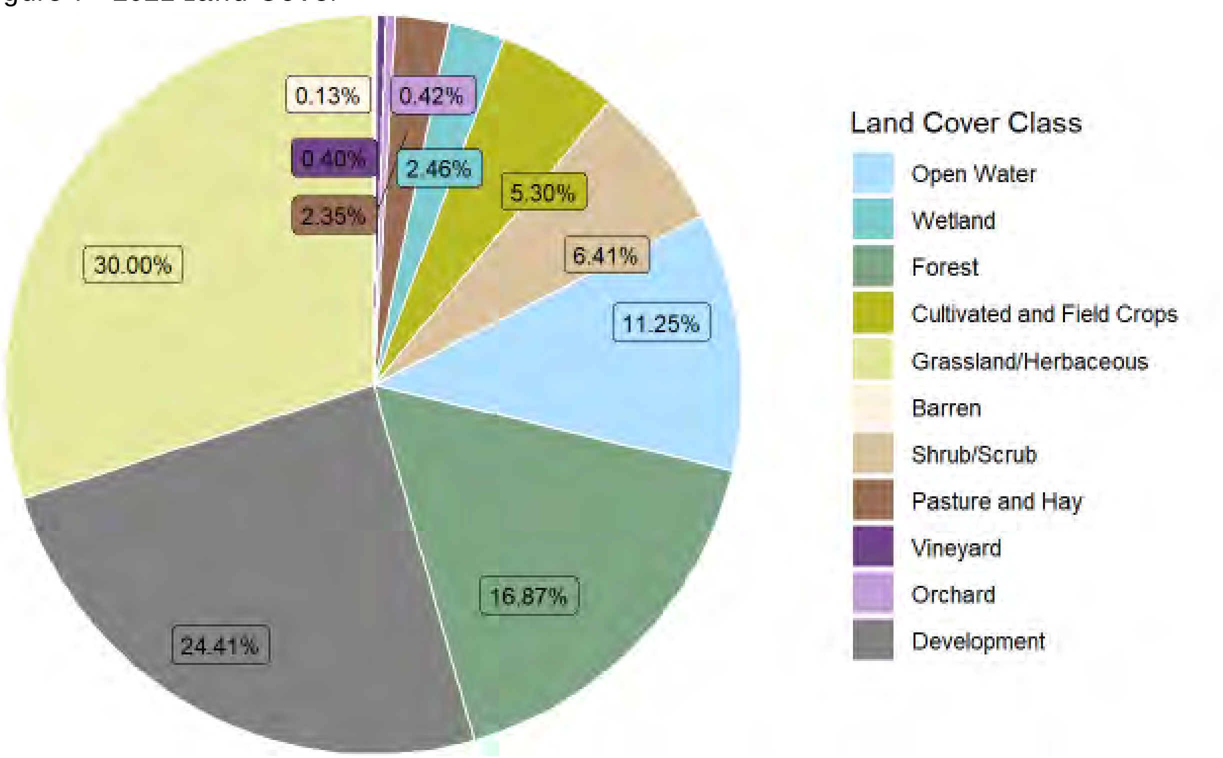


Figure 8 Land Cover Class as Percent of Total Land Area (2001 and 2021)

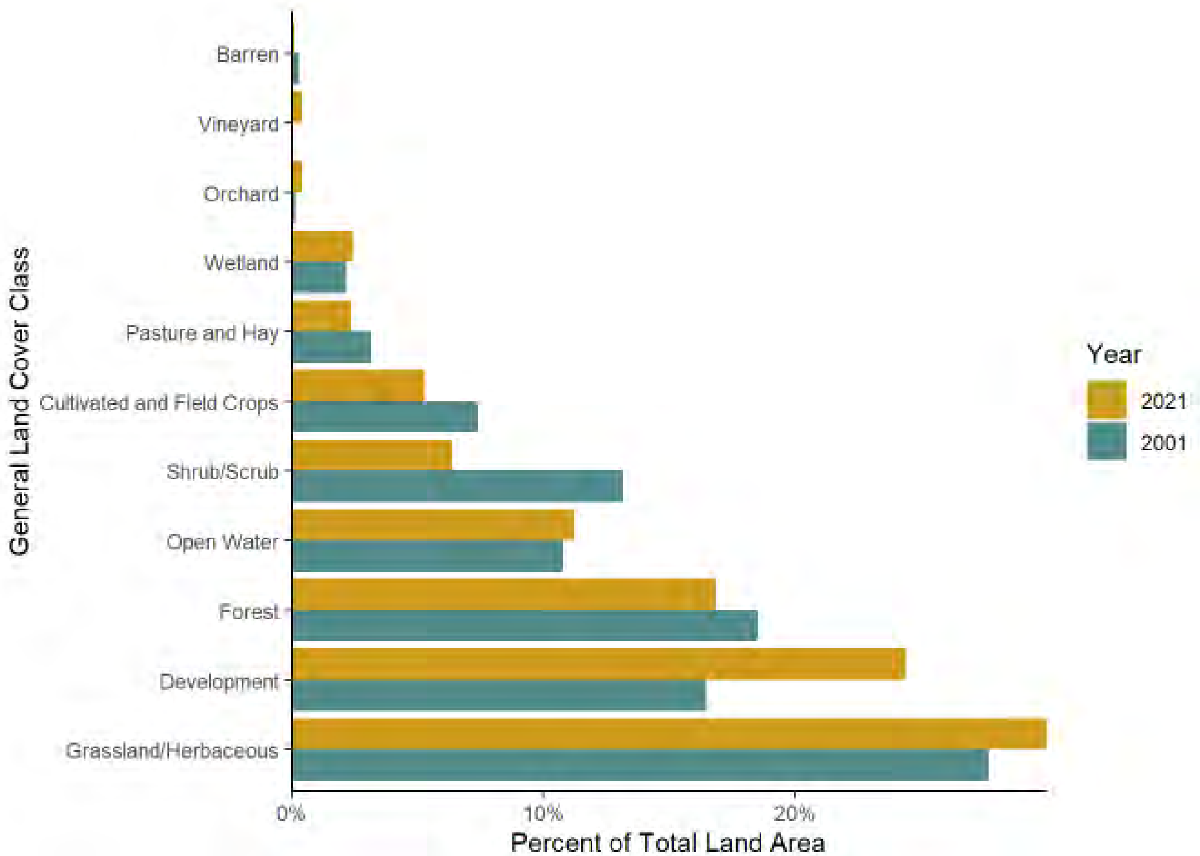


Table 3 Land Cover Class Acreage (2001 and 2021)

Land-cover Class	2001 Acres	2021 Acres	Percent Change
Barren	1,551	697	-55
Cultivated and Field Crops	38,354	27,342	-29
Development	85,072	125,993	48
Forest	95,607	87,106	-9
Grassland/Herbaceous	142,921	154,839	8
Open Water	55,688	58,062	4
Orchard	814	2,162	166
Pasture and Hay	16,347	12,143	-26
Shrub/Scrub	68,159	33,107	-51
Vineyard	341	2,060	503
Wetland	11,331	12,677	12
Total	**516,185**	**516,185**	**–**

Acres have been rounded and therefore sums may not match.

Additional Stakeholder Feedback and Conflicting Study Results

While an extensive QA/QC process was conducted with multiple stakeholders of the LANDFIRE datasets, some the results of the landcover trend analysis were not consistent with trends seen on the ground by experts in Contra Costa County. And due to the size of the dataset, it is unfeasible to QA/QC every parcel within Contra Costa County. Consequently, additional revisions to the dataset were not made because they may not have provided different results. Therefore, changes in LANDFIRE classification between years, including misclassifications that remain after QA/QC in one of the two baseline years (2001 and 2021), may create false trends in land cover change over time. After the analysis for the Carbon Feasibility Study was complete, trends in grassland and shrubland land cover were questioned by stakeholders with local knowledge of land use change. For example, by using the LANDFIRE Map Viewer, attachment 2881 was assessed to spot check the land cover classification accuracy for the two baseline years against satellite imagery of the site. LANDFIRE classified this site as Southern California Coastal Shrub in 2001, but classifies it as grassland in 2021. This would indicate that shrubland has been lost to grassland over the baseline assessment period. Figure 9 shows the site in 2002, and Figure 10 shows the site in 2022. It is clear from the satellite imagery that the area should have been classified as grassland in 2001.

Figure 9 Satellite Imagery of Contra Costa County Sample Site in 2002

Figure 10 Satellite Imagery of Contra Costa County Sample Site in 2022

The new housing development seen in Figure 10 takes up roughly 20-acres. In order to reflect this, LANDFIRE should classify this area as a 70-acre grassland that became a 20-acre development and 50-acre grassland, rather than a 70-acre shrubland that was reduced to a 50-acre grassland and 20-acre development. This is an example of the small-scale inaccuracies in LANDFIRE classification that can create false trends when two baseline years are compared at the landscape level.

Additionally, the results from the LANDFIRE analysis for changes in grassland and shrubland was counter to the prevailing experience of local stakeholders, and alternative reports tracking land use change. Experts from both the UCCE and RCD with local knowledge of Contra Costa County agricultural land use and trends expressed that the consensus experience and observations from many ranchers, farmers, and land managers is that decreases in grazing pressure and fire suppression have resulted in loss of grassland to shrubland, and not the reverse. Furthermore, local experience is that development is more likely to occur on grassland than on shrubland. Therefore, local knowledge and experience would indicate that land cover trends should show decreases in grassland and rangelands over time, and that shifts from shrub to grass are unlikely outside of fire perimeters or land clearing activities. There is at least one research study that also supports this understanding of land cover changes.

A study conducted in 2003 looked at seven sites throughout the rangelands of San Francisco Bay Area, using aerial photography of each site from previous years to assess changes in vegetation over time. The study confirmed that fire suppression and reduced grazing pressure had resulted in increases of shrubs on lands previously dominated by grasses[22].

While rangelands include multiple land dover types (grassland, forest (oak savannah and oak woodland), shrubland, etc), trends in rangeland can provide supportive evidence for expected trends in grassland. The California Department of Conservation tracks data for important farmland, including for Contra Costa County, through the Farmland Mapping and Monitoring Program. A table summarizing historic land use conversion or important farmland landcover types[23] indicates that in 2000 there were 172,924 acres of grazing land (which may be comprised of multiple land cover classifications in addition to grassland) and 157,424 acres of grazing land in 2018 (the most recent year for which data were available). This data indicates a decline in grazing land of 15,500 acres during that 18-year time span, which would likely include a large proportion of grassland. The Contra Costa County Agricultural Department prepares annual crop and livestock reports. The oldest and most recent crop reports available through the County website were for 2013 and 2019, and those reports include year over year comparisons, so the 2013 report includes 2012 crop data. Comparisons of irrigated pasture and non-irrigated rangelands acreages from those two years also indicate a trend of reduced rangeland acreages, while irrigated pasture remained constant. In 2012 there was approximately 5,450 acres of irrigated pasture and 169,000 acres of rangeland pasture. In 2019, there was still 5,450 acres of irrigated pasture but 149,000 acres of rangeland pasture, a decrease of 20,000 acres of rangeland. While neither of these reports are exclusively applicable to changes in grassland, the findings in combination with local expertise and the study mentioned previously, would suggest that grassland acreage is decreasing over time.

LANDFIRE data is currently used at the national level, and state level, and has been used in similar carbon feasibility assessments for other counties including Merced and Santa Barbara Counties. LANDFIRE data is intended for use in regional land use planning including for carbon sequestration assessments. Given the available data sources, and regular updates to the datasets, LANDFIRE data was considered the best available base data set for this analysis and was updated with additional data sets and corrections were made during the QA/QC process. However, some inaccuracies with classification still remained in the final assessment. These discrepancies run counter to the prevailing knowledge and local experience. Given that cattle are the top agricultural product by economic value in Contra Costa County, and the concerns raised with the trends in grassland and shrubland, the County has decided to use the 2021 land cover analysis as the baseline for the final report. The land cover analysis for 2001 remains in this technical memorandum for informational purposes and serves as an appendix to the Carbon Feasibility Report.

[22] William H. Russell, Joe R. McBride, Landscape scale vegetation-type conversion and fire hazard in the San Francisco bay area open spaces, Landscape and Urban Planning, Volume 64, Issue 4, 2003, Pages 201-208, https://doi.org/10.1016/S0169-2046(02)00233-5

[23] Important farmland landcover types differ from the landcover classification used by LANDFIRE and other data sources referenced in this memo.

Next Steps

Land-based Carbon Inventory Methodology

The 2021 land-based carbon inventory will follow the methodology outlined in Resilient Merced, California's 2017 Climate Change Scoping Plan, and the State's Natural and Working Lands Inventory.[24,25,26] Resilient Merced, which resulted from a collaboration between Merced County, The Nature Conservancy, and the California Department of Conservation, outlines the methodology used in Merced County to inventory carbon stored in natural and working lands. The 2021 inventory of carbon stocks for natural and working lands (land-based carbon inventory) in Contra Costa County will cover the County's 516,185 acres, which includes all natural, agricultural, and urban areas.

Land-based Carbon Inventory

Carbon Stock Estimates

Carbon stock estimates are based on the sum of carbon stored in different carbon pools. Carbon stock analysis includes carbon stored in the following carbon pools:

- Above- and below-ground live biomass
- Above- and below-ground dead standing trees
- Lying dead wood (e.g., branches, logs, etc. lying on the ground surface)
- Litter (e.g., freshly fallen or slightly decomposed leaves, bark, twigs, flowers, fruits, and other vegetable matter).
- Soil

Carbon stored in all above- and below-ground biomass (including live, dead, and litter), is calculated using volumetric estimates of carbon mass (metric tons per hectare) provided by the California Air Resources Board (CARB).[27] These estimates will be provided for every combination of Existing Vegetation Type, Height, and Cover and assigned to each 30 by 30-meter cell in the County. The carbon values are then summed within each land-cover class. For example, the above- and below-ground carbon stored in annual crops is 0, because they are harvested annually, however, berries, vineyards, orchards do maintain a carbon stock and therefore have higher carbon value than annual crops. The carbon value for all cultivated crops is then summed to provide the total carbon stored in that land-cover class.

Soil Carbon

Soil carbon values are obtained using the combined NCSS Characterization Database, the National Soil Information System (NASIS), and the Rapid Carbon Assessment (RaCA) datasets described in the Data

[24] California Department of Conservation, The Nature Conservancy, Tukman Geospatial, Climate Action Reserve, and Merced County. 2018. Resilient Merced. Available: https://maps.conservation.ca.gov/TerraCount/downloads/. Accessed March 11, 2022.
[25] California Air Resources Board (CARB). 2017. California's 2017 Climate Change Scoping Plan. Available: <https://ww2.arb.ca.gov/sites/default/files/classic//cc/scopingplan/scoping_plan_2017.pdf Accessed March 11, 2022.
[26] CARB. 2018. An Inventory of Ecosystem Carbon in California's Natural and Working Lands. Available: <https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf>. Accessed March 11, 2022.
[27] Volumetric estimates of carbon mass were provided by Klaus I. Scott, Emission Inventory Analysis Section of the Greenhouse Gas & Toxics Emission Inventory Branch, AQPS Division at CARB on November 17, 2020.

Evaluation section of this memorandum.

The soil carbon inventory estimates are determined by using the values provided for soil organic carbon and soil bulk density at a depth of 0-30 centimeters.[28] The soil organic carbon estimates are calculated as described in Quantification Guidance for Use with Forest Carbon Projects report from the CAR FPP Quantification Guidance Version 4.0, as shown in the following equation (the Conversion of Organic Matter to Carbon step was skipped as the input data was provided as Soil Organic Carbon):[29]

Soil CO_2e	=	Organic Matter Value (Steps 2 or 4) **x** 0.58 (Conversion of Organic Matter to Carbon) **x** Bulk Density Value (Steps 3 or 5) **x** Soil Depth Sampled (30 cm) **x** 40,468,564.224 (Conversion of 1 cm^2 to 1 acre) **x** 10^{-6} (Conversion of 1 gram to 1 metric ton) **x** 3.67 (Conversion of Carbon to CO_2)

Land-based Emissions

GHG inventories for agriculture, forestry, and land use generally include the following emissions categories:

- Changes in soil carbon stocks
- Nitrous oxide emissions from soils (including fertilizers), biomass burning, and drained organic soils
- Changes in woody biomass carbon stocks
- Methane emissions from wetland, rice cultivation, and biomass burning
- Carbon dioxide emissions from burning, liming, urea fertilization, and drained organic soils
- Carbon monoxide emissions from biomass burning

For the purposes of the Contra Costa County Land-based Carbon Inventories, only methane emissions associated with wetlands will be estimated. Emissions associated with fertilizer application for agricultural uses are included in the County's Community GHG Inventory, therefore including them in this analysis would result in double-counting emissions. Changes in GHG emissions over time are driven by both changes in land use and in land management practices. Temporal data on land management activities is largely unavailable, therefore changes in GHG emission from 2001 to 2021 will be driven by land use change.

Emissions from wetlands will be estimated for 2001 and 2021, and the difference between those two years will be calculated as the baseline reference projection.

The level of methane emissions varies depending on whether wetlands are inundated continuously or intermittently. Continuously inundated wetlands have estimated methane emissions of 16.02 tonnes per hectare per year (carbon dioxide equivalent), while intermittently inundated wetlands have estimated methane emissions of 3.53 tonnes per hectare per year (carbon dioxide equivalent).[30] Nitrous oxide (N_2O) emissions from wetlands are very low, absent the input of organic or inorganic nitrogen

[28] A portion of soil organic carbon is located below 30 centimeters, and management practices that lead to enhanced carbon storage in both shallow and deep soils will be included in the carbon sequestration feasibility assessment for this project.

[29] Climate Action Reserve. 2017. Quantification Guidance for Use with Forest Carbon Projects. Available: <https://www.climateactionreserve.org/wp-content/uploads/2017/07/FPP_Quantification_Guidance_062817.pdf>. Accessed March 11, 2022.

[30] 2013 supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. 2013. IPCC. Available: < https://www.ipcc.ch/site/assets/uploads/2018/03/Wetlands_Supplement_Entire_Report.pdf >. Accessed March 17, 2022.

from runoff.[31] N_2O emissions are assumed to be de minimus for Contra Costa County. The table below shows the variation in methane emissions based on annual period of inundation for wetlands. The calculations below show how to estimate methane emissions from wetlands.

TABLE 5A.2.3
CH_4 EMISSIONS FROM TEMPERATE, REWETTED, CREATED AND NATURAL WETLANDS WITH IWMS, STRATIFIED BY PERIOD OF INUNDATION

Climate region	Annual period of inundation	Mean CH_4 emission ($kg\ CH_4\ ha^{-1}\ yr^{-1}$)	Standard deviation	95% confidence interval[A]	Number of studies
Temperate	Continuous	572	191	±125	5[B]
	Intermittent	126	108	±75	14[C]

Note: All values are derived from studies of temperate wetlands listed in Table 5A.2.1.

A The 95% confidence interval is calculated from the mean, standard deviation, and the critical values of the t distribution, according to the degrees of freedom.

B The studies used to determine this value are listed in Table 5A2.1; Kim et al., 1999; Song et al., 2003 (*Carex* marshes); Ding and Cai, 2007; Altor and Mitsch, 2008; Nahlik and Mitsch, 2010.

C The studies used to determine this value are listed in Table 5A2.1; Pulliam, 1993; Bartlett and Harriss, 1993 (n=3 wetland types); Song et al., 2003 (*Deyeuxia* marshes); Song et al., 2009 (n=2 wetland types); Huang *et al.*, 2010; Badiou *et al.*, 2011; Pennock *et al.*, 2010; Gleason *et al.*, 2009; Morse *et al.*, 2012; Herbst *et al.*, 2011; Yang *et al.*, 2012.

EQUATION 3a.3.1
CO_2 EMISSIONS IN WETLAND REMAINING WETLAND

$$CO_2\ emissions_{WW} = CO_2\ emissions_{WW\ peat} + CO_2\ emissions_{WW\ flood}$$

Where:

$CO_2\ emissions_{WW}$ = CO_2 emissions in wetland remaining wetland, $Gg\ CO_2\ yr^{-1}$

$CO_2\ emissions_{WW\ peat}$ = CO_2 emissions from organic soils managed for peat extraction (Section 3a.3.1), $Gg\ CO_2\ yr^{-1}$

$CO_2\ emissions_{WW\ flood}$ = CO_2 emissions from flooded land (Section 3a.3.2), $Gg\ CO_2\ yr^{-1}$

At present, a default methodology for CH_4 can be provided only for flooded land (Equation 3a.3.3):

EQUATION 3a.3.3
METHANE EMISSIONS FROM WETLANDS REMAINING WETLANDS

$$CH_4\ emissions_{WW} = CH_4\ emissions_{WW\ flood}$$

Where:

$CH_4\ emissions_{WW}$ = CH_4 emissions from wetlands remaining wetlands, $Gg\ CH_4\ yr^{-1}$

$CH_4\ emissions_{WW\ flood}$ = CH_4 emissions from flooded land (Section 3a.3.3), $Gg\ CH_4\ yr^{-1}$

[31] 2013 supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. 2013. IPCC. Available: < https://www.ipcc.ch/site/assets/uploads/2018/03/Wetlands_Supplement_Entire_Report.pdf >. Accessed March 17, 2022.

Baseline Projections

Results from the carbon inventories are used to project baseline land-cover acreage and carbon stock out to 2030 using a linear regression, as outlined in Resilient Merced. This projection is not inteded to predict what will happen in the future, but rather provide a business as usual (BAU) baseline scenario in which carbon stocks continue to change at the same rate as they did from 2001 to 2021. **However, due to the concerns raised with the trends in grassland and shrubland, the County has decided to showcase the projections from 2001 to 2021 for informational purposes only.**

Many factors including climate change and policy implementation, will determine potential future trends in carbon stock. The year 2030 aligns with the State of California's climate goals and targets and acts as a near-term projection against which land management activities can be implemented, tracked, assessed, and modified to increase carbon stocks in the county.

Conclusion

This memorandum provides a summary of the data used for the land classification analysis, the results for the County's 2001 and 2021 land classification analysis and proposed methodology for the land-based carbon inventories and baseline projection. Based on Rincon's review of the provided data, it appears that the data are generally complete and appropriate for use in the County's land classification analysis and carbon inventory. And due to concerns raised with the trends in grassland and shrubland, projections from 2001 to 2021 will not be included in the Carbon Feasibility Report. The land cover analysis for 2001 remains in this technical memorandum for informational purposes. Upon review of this memorandum and approval from the County, Rincon will complete and provide the land-based carbon inventories and baseline projection exercise to the County for review. Please let us know if you have any questions, comments or concerns with the data or methodology used in the County's land classification, or proposed for use in carbon inventories and baseline projection.

Sincerely,
Rincon Consultants, Inc.

Camila Bobroff
Sustainability Planner/Assistant Project Manager

Lexi Journey
Senior Planner/Project Manager

Erik Feldman, MS, LEED AP
Principal

Appendix E

Contra Costa County Land Cover Trends, Carbon Stock and GHG Emissions Inventory Results and Forecast Memorandum

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TOC

June 29, 2022
Amended: June 2023
Project No: 21-11493

Jody London, Sustainability Coordinator
Contra Costa County
30 Muir Road
Martinez, California 94553
Via email: Jody.London@dcd.cccounty.us

Subject: Contra Costa County Land Cover Trends, Carbon Stock and GHG Emissions Inventory Results and Forecast Memorandum

Dear Ms. London,

Rincon Consultants, Inc. (Rincon) has completed the carbon stock, greenhouse gas (GHG) emissions estimates and forecasting phase of the carbon sequestration feasibility study for Contra Costa County (County) and has summarized the results of this phase in this memorandum. The memorandum includes the carbon stock and GHG emissions inventories for 2001 and 2021, in addition to the baseline reference scenario, which uses historical land cover changes to project carbon stock and GHG emissions out to 2030. The land-based carbon inventories were developed based on methodology presented in Resilient Merced, [1] California's 2017 Climate Change Scoping Plan, [2] and California's 2018 Natural and Working Lands Inventory.[3] These sources identify principles to guide the quantification of carbon stored in, and emitted from, natural and working lands in a complete, accurate, consistent, and transparent manner. This memorandum includes the following sections:

- Introduction and Background – Overview of evaluating carbon stored in natural and working lands and Summary of Contra Costa County and regional land use policies and development trends
- Data Evaluation – a summary overview of the data sources underlying all analysis, and the quality assurance and quality control (QA/QC) refinements made as a result of data assessment and quality control measures
- Methods and Findings
  - Land cover classification methodology and results summary for 2001 and 2021
  - Carbon Inventories – methods and findings related to the land cover classification process and derived carbon stock estimates for 2001 and 2021
  - Baseline Projections – methods and findings related to the establishment of the baseline reference scenario, or baseline projection

[1] California Department of Conservation, The Nature Conservancy, Tukman Geospatial, Climate Action Reserve, and Merced County. 2018. Resilient Merced. Available: https://maps.conservation.ca.gov/TerraCount/downloads/. Accessed March 11, 2022.
[2] California Air Resources Board (CARB). 2017. California's 2017 Climate Change Scoping Plan. Available: <https://ww2.arb.ca.gov/sites/default/files/classic//cc/scopingplan/scoping_plan_2017.pdf>. Accessed March 11, 2022.
[3] CARB. 2018. An Inventory of Ecosystem Carbon in California's Natural and Working Lands. Available: <https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf>. Accessed March 11, 2022.

- Conclusion – a summary of next steps including complementary benefits and land management activities to be analyzed

Introduction and Background

Evaluating Carbon Stored in Natural and Working Lands

Natural and working lands management is an emerging focus for local climate action planning efforts across California. Strategic natural and working lands management can help maintain existing carbon stock and mitigate land-use related GHG emissions via carbon sequestration. This contribution to carbon sequestration is important for the state's ability to achieve its carbon neutrality goal established by Executive Order B-55-18, to achieve carbon neutrality by 2045.[4]

Jurisdictions across California will need to increase efforts to conserve, restore, and manage forests, rangelands, farms, urban green spaces, and wetlands, and promote the development of healthy soils in order to support collective efforts to achieve this ambitious target. The land-based carbon stock is the total amount of carbon sequestered in woody and herbaceous material and in the soil. The purpose of this memorandum is to provide Contra Costa County with an overview of the historical trends in land cover for two years (2021 and 2001), as well as the land-based carbon inventories results, a review of County development trends, and forecasts for land cover changes, carbon stocks, and GHG emissions.

The Contra Costa County carbon inventories and baseline reference projection followed the methodology outlined in Resilient Merced, California's 2017 Climate Change Scoping Plan, and the State's Natural and Working Lands Inventory.[5,6,7] A land-based carbon inventory provides a quantitative estimate by land cover class (e.g., forest, grassland, etc.) of carbon stocks, stock-changes, and resulting GHG sequestered or emitted from different stock changes. The land-based carbon inventory is based on estimates of above and below-ground biomass and soil carbon for each land cover class. The soil data used in this analysis currently only provides information for a snapshot in time (2017), and therefore, changes in soil carbon between the two inventories are not captured in the inventories. As new soil carbon data is released in the future, changes in soil carbon, for example through carbon sequestration, could be captured in future inventories. For more information on data used, refer to the data evaluation memorandum submitted to the County on May 2022. Land-based sequestration of carbon is associated with land management practices including compost application, cover crops, and planting. Sequestration from agricultural practices is not included in this inventory because there are no publicly available, regularly updated spatial data sets to estimate carbon sequestration across Contra Costa County.[8] Land-based emissions exist in the form of methane and nitrous oxide, which are associated with wetlands and agricultural practices such as fertilizer application. Emissions from agricultural practices are not included in the Contra Costa County carbon inventories because these are already included in the County's 2017 Community GHG Emissions Inventory and including these emissions in the

4 State of California Executive Department. 2018. Executive Order B-55-18 to Achieve Carbon Neutrality. Available: https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf . Accessed March 11, 2022.
5 California Department of Conservation, The Nature Conservancy, Tukman Geospatial, Climate Action Reserve, and Merced County. 2018. Resilient Merced. Available: https://maps.conservation.ca.gov/TerraCount/downloads/. Accessed March 11, 2022.
6 California Air Resources Board (CARB). 2017. California's 2017 Climate Change Scoping Plan. Available: <https://ww2.arb.ca.gov/sites/default/files/classic//cc/scopingplan/scoping_plan_2017.pdf>. Accessed March 11, 2022.
7 CARB. 2018. An Inventory of Ecosystem Carbon in California's Natural and Working Lands. Available: <https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf>. Accessed March 11, 2022.
8 The next phase of this project is to assess the carbon sequestration potential of different land management practices.

land-based carbon inventory would result in double-counting.[9] However, emissions from wetlands are not included in the Community GHG Emissions Inventory and are therefore, calculated as part of the land-based carbon inventory.

The carbon inventories estimate carbon at two points in time (2001 and 2021) to establish the baseline reference projection, or baseline projection, for Contra Costa County. The baseline projection represents the business-as-usual (BAU) condition for the land cover types in the County which can serve as a benchmark for assessing the relative impact of land cover change over time. The baseline projection is calculated using a linear regression, which assumes that the same rate of land cover changes that occurred between 2001 and 2021 will occur in the future, and therefore does not assume any changes in management practices. Evaluating the current land-based carbon stock and carbon sequestration potential of land management activities will establish a baseline that allows for future analysis of carbon sequestration and the development of GHG emission reduction strategies and projects.

Contra Costa Land Use Policies and Development Trends

Contra Costa County stretches over 516,185 acres of land and water, which includes all natural, agricultural, and urban areas, and water included? both incorporated and unincorporated. Regional and local trends and policies help to shape how this land is developed or maintained for different uses over time, including the loss or preservation of agricultural and working lands, and open spaces. Given that the County's open spaces can serve to sequester or emit GHG emissions, changes in land-use have the potential to impact the County's ability to reach its Climate Action Plan (CAP) targets. The emissions

reduction targets established in the 2015 CAP are for the County to reduce community-wide emissions to 15% below 2005 levels by 2020, and in alignment with SB 32, to reduce emissions to 40% 1990 levels by 2030 and continue along this reduction trajectory to reduce emissions to 50% below 1990 levels by 2035. To achieve the 2035 target would require the County to reduce carbon dioxide (CO_2) emissions by 626,630 metric tons. The County is currently developing an updated Climate Action Plan update that is expected to be completed in 2023. The 2023 CAP will provide the County's updated strategies and actions to reduce greenhouse gas (GHG) emissions and will include updated County emissions targets that meet or exceed the per capita minimum regulatory targets set forth by the state as well as some aspirational targets. The Contra Costa County Interim Climate Action Work Plan for 2021-2022 served to focus County action and provide the metrics for measuring progress across several key areas (built environment, resilient communities and natural infrastructure, waste reduction, water conservation and drought resilience, transportation, climate equity, and leadership) while the 2023 CAP is being developed. As of the 2021 Progress Report[10] the County was expected to meet the majority of the interim work plan goals by 2022.

As population grows, the housing and transportation needs of a community grow. Buildings and transportation are two of the largest sectors for community GHG emissions. With strategic planning and policy, the GHG emissions associated with additional transportation and building development can be managed to maintain progress towards achieving GHG emission reductions, despite growth in these two sectors. The sections below describe the regional and County policies and plans that will influence how

[9] Contra Costa County. 2019. Greenhouse Gas Emissions Inventory. Available: < https://envisioncontracosta2040.org/wp-content/uploads/2019/04/Sustainability-Commission-04-22-19-CAP-Memo.pdf>. Accessed March 11, 2022.

[10] Contra Costa County. 2021. Contra Costa County Interim Climate Action Plan 2021 Progress Report. December 13, 2021. Available: https://www.contracosta.ca.gov/DocumentCenter/View/73926/Annual-Report---Interim-CAP---Final---Rev-1?bidId=. (May 2022)

land use change, housing development, and transportation will impact the County's ability to meet its community emissions targets.

Jobs, Housing and Transportation Needs

Three elements that drive development and influence land use planning (and consequently, GHG emissions) across the County and region are the number and location of jobs, housing units, and transportation between housing and employment centers. The Association of Bay Area Governments (ABAG) and Metropolitan Transportation Commission (MTC) adopted a preferred land-use scenario in November of 2017. Analysis indicated that housing construction was lagging far behind job creation with an average of only 1 new housing unit built for every 8 jobs created between 2011 and 2015. The region is projected to need 820,000 new housing units by 2040. This imbalance between jobs and housing stimulates strong demand for new units, increasing development pressure. ABAG developed a Growth Geographies map with input from local jurisdictions to identify priority development areas for the fulfillment of longer-term housing needs.

ABAG also facilitates the shorter-term Regional Housing Needs Allocation (RHNA) housing development requirements as approved by the California Department of Housing and Community Development (HCD) amongst the Bay Area jurisdictions every eight years. The housing requirements allocated to unincorporated Contra Costa County in 2013 indicated that the County would have to provide 1,367 new units by 2022, distributed among four income categories. 1,525 new housing units have been built since 2015; however, units in the above-moderate income group were over-produced, while the lower income group housing units were under-produced. In December 2021 the final RHNA for the 2023-2031 cycle was adopted. The unincorporated County must provide a total of 7,610 additional housing units across the four income categories. In order to meet housing these needs while preventing loss of open spaces, and working and agricultural lands, the preferred land use scenario indicated several strategies including focusing on infill development centered around transportation infrastructure, and maintaining urban growth boundaries. The Plan Bay Area 2050[11] housing plan similarly calls for tailoring design and density of new homes to increase density with area-appropriate infill development and the maintenance of urban growth boundaries established by jurisdictions through 2020.

In order to accommodate the transportation needs for the additional commuters, transit funding was proposed to be primarily utilized for operating, maintaining, and modernizing the Bay Area transportation system, including increasing the frequency and capacity of BART trains and keeping all forms of transit in "good repair." The focus areas for future housing and jobs growth identified in the Plan Bay Area 2050 Growth Geographies are centered around existing job centers and transit-rich areas. The plan also includes strategies for building a "Complete Streets" network to meet the needs of pedestrians, bicyclists and drivers in order to increase alternate modes of transportation and alleviate traffic congestion for growing neighborhoods, while also reducing transportation related GHG emissions.

Transportation is one of the largest sources of GHG emissions for most communities. Planning new developments that minimize the distance between housing and public transportation hubs, employment centers, and other amenities reduces the number of miles that need to be driven by commuters and community members. Creating streets that are safe and easily navigable for bicyclists and pedestrians helps to encourage these alternative modes of transportation further reducing the number of miles

[11] MTC and ABAG. October 2021. Plan Bay Area 2050: A Vision for the Future. Accessible: <https://www.planbayarea.org/sites/default/files/documents/Plan_Bay_Area_2050_October_2021.pdf> (May 2022)

driven. By decreasing the number of miles travelled in fossil fuel powered vehicles the GHG emissions related to transportation can be decreased.

Natural and Working Lands

The Plan Bay Area 2050 Environment Chapter recognizes that open spaces outside of the region's urban footprint provide not only health benefits and a limit to urban sprawl, but also support climate goals, and improve watershed management., provide habitat, and support biodiversity. Regional funds that augment local investments to conserve and manage critical lands would support a regional goal of protecting and maintaining over 2 million acres of open space by 2050. As mentioned above, Plan Bay Area 2050 maintains the urban growth boundaries established by local jurisdictions and counties as of 2020 to direct new growth within the existing urban footprint to limit sprawl and preserve open spaces. Natural and working lands may be both a source of carbon emissions or a sink for carbon. Directing new growth within existing urban footprints and preserving open space prevents the emission of carbon stored in natural or working lands when they are converted to other uses. Preserving natural and working lands also preserves the opportunity to enhance carbon sequestration through the adoption of strategic management practices that increase the amount of carbon stored in soil and vegetation. Land use policy and land management are important avenues for managing these lands to achieve GHG emissions reductions along with the recreational, health, and environmental benefits they bring the community.

Alignment in Regional and County Trends and Policy

Contra Costa County's existing General Plan was adopted in 1991. The County Department of Conservation and Development (DCD) has been working on a comprehensive update to the County General Plan, Zoning Code, and 2023 Climate Action Plan (CAP), called "Envision Contra Costa 2040." The updated General Plan is expected to be completed in 2023 and will provide the County's long-term sustainability and resiliency goals, policies, and actions. The updated General Plan will address sustainability, community health, environmental justice, resource protection, preservation and conservation of open space, among other things, while continuing to balance growth with conservation. The regional policies and plans outlined above are highly aligned with the Envision Contra Costa 2040 draft Land Use policies and the draft Conservation, Open Space, and Working Lands policies publicly available as of May 2022.

The draft Land Use element maintains the Urban Limit Line (ULL), and the 65/35 Land Preservation Standard.[12] The ULL was originally established by County voters through the adoption of Measure C-1990. The ULL establishes a line beyond which no urban land uses can be designated to ensure preservation of identified non-urban agricultural, open space, and other areas, and facilitates enforcement of the 65/35 Standard. Proposed policies will limit development outside of the ULL to non-urban uses including agriculture and encourage infill development in already developed areas. Proposed policies also support new housing development in existing residential and employment-rich areas, and encourage development that is mixed-use, transit oriented, and designed to encourage utilization of alternative modes of transportation.

The draft Conservation, Open Space, and Working Lands policies indicate that the County is prioritizing the preservation and enhancement of natural lands and open spaces, including efforts to encourage the

[12] The 65/35 Land Preservation Standard limits development to that no more than 35% of the County's land.

revegetation of native species and compost application on disturbed lands, planting and propagation of native trees, and supporting native oak populations in the woodland areas. Additionally, the County has draft policies for preserving ecological resources through studies and limits on development, for protecting and restoring natural watercourses, riparian corridors, and wetland areas, and for supporting agriculture in the County.

Data

Jurisdictional carbon inventories require the use of large-scale spatial data sets and carbon or biomass data that is accurate, consistent, and available for past and present years and into the future. The Contra Costa County carbon inventories use publicly available data sources that are expected to be updated in the future. Table 1 and Figure 1 includes the data sources used to complete the Contra Costa County 2001 and 2021 land cover analysis that is the basis for the Countywide carbon inventories and baseline projection. For additional information, please refer to the data evaluation memorandum which discusses data evaluation at length.

Table 1 Data Sources Used

Land Type	Data Name and Developing Agencies	Publication Frequency	Year
Natural Lands (Forest, Shrubland, Grassland, etc.), and Agricultural Lands (Pasture and Hay, Orchards, Cultivated Crops, and Vineyards)	LANDFIRE[1] developed, in part, by the United States Department of Agriculture (USDA) Forest Service and the United States Department of the Interior.	2 years	2001, 2021
	Multi-Resolution Land Characteristics Consortium (MRLC) – National Land Cover Database (NLCD)[2] developed by a group of federal agencies. Partners include the United States Bureau of Land Management, National Agricultural Statistics Service (NASS), National Oceanic and Atmospheric Administration (NOAA), USDA Forest Service and the United States Geological Survey.	5 years	2001, 2021
Urban Forest	i-Tree Canopy (v7.1)[3] developed, in part, by the USDA Forest Service.	Annual	2021
Soil	NCSS Characterization Database, the National Soil Information System (NASIS), and the Rapid Carbon Assessment (RaCA) datasets[4] developed, in part, by the National Soil Survey Center (NSSSC), Kellogg Soil Survey Laboratory (KSSL), USDA, and National Resource Conservation Service (NRCS).	N/A[5]	2017

[1] LANDFIRE data - https://www.landfire.gov/

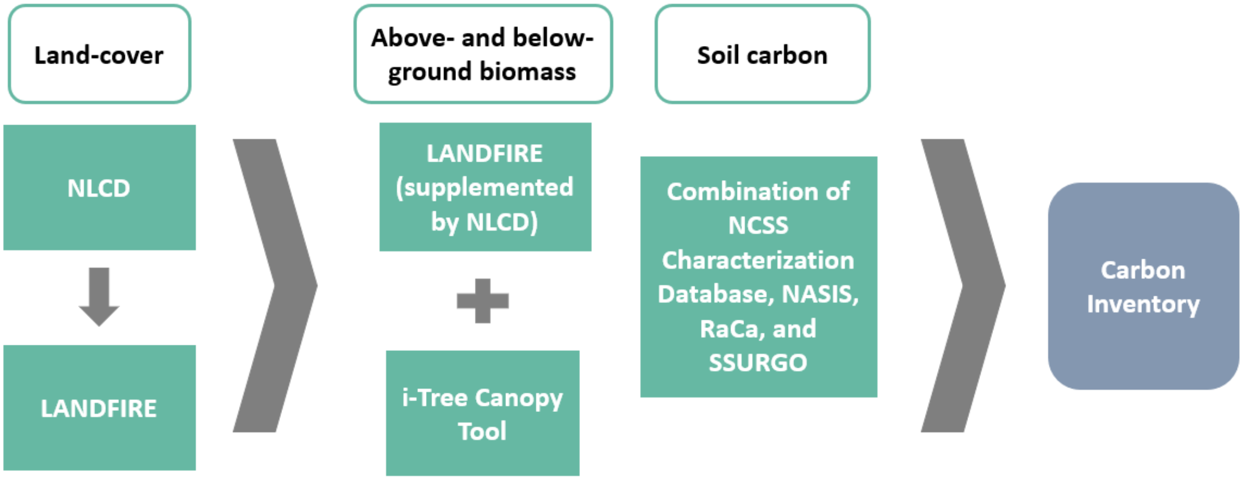
[2] NLCD data - https://www.mrlc.gov/data?f%5B0%5D=category%3ALand%20Cover

[3] i-Tree Canopy Tool - https://canopy.itreetools.org/

[4] Soil data - https://scholarsphere.psu.edu/resources/ea4b6c45-9eba-4b89-aba6-ff7246880fb1 Ramcharan A.,Hengl T., Nauman T., Brungard C., Waltman S., Wills S., Thompson J. (2017) Soil Property and Class Maps of the Conterminous US at 100 meter Spatial Resolution based on a Compilation of National Soil Point Observations and Machine Learning. Submitted to Soil Science Society of America Journal.

[5] Currently a snapshot in time for 2017 – future updates not planned.

Figure 1 Data Used for the Contra Costa County Inventories (2001 and 2021)



Quality Assurance and Quality Control (QA/QC)

Given the importance of the underlying data in driving the results of the carbon inventories, Rincon consultants undertook quality assurance and quality control measures. Data availability and quality were assessed throughout the collection and land classification analysis process through input from stakeholders, spatial analysis, and desktop ground truthing.

Agricultural Land Classification

The following four data sources were reviewed for agricultural land classification:

- LANDFIRE
- USDA Cropland Data Layer[13]
- Census of Agriculture[14]
- County Crop Reports

Data Source Results Comparison

County Crop reports are likely to be the most accurate crop dataset providing acreages for different agricultural land uses because they are locally developed by reviewing permits and speaking to growers and ranchers in the County. Rincon reviewed the agricultural acres for 2021 from the data sources listed above and determined that out of the two spatial datasets (LANDFIRE and USDA Cropland Data Layer) LANDFIRE agricultural land cover was best aligned with the County Crop Report based on acreage.

LANDFIRE Inaccuracies

Inaccuracies were identified in LANDFIRE's classification of grassland/herbaceous land cover, therefore, NLCD and satellite imagery was used to identify potentially misclassified areas. Cells with mismatched LANDFIRE and NLCD categories were reclassified to the values of the nearest LANDFIRE cell of that type

[13] USDA Cropland Data Layer. 2021. Cropscape. Available: < https://nassgeodata.gmu.edu/CropScape/>. Accessed March 1, 2022.
[14] USDA Census of Agriculture. 2019. Census of Agriculture Historical Archive. Available: <https://agcensus.library.cornell.edu/census_parts/2002-california/>. Accessed March1, 2022.

within 2,000 feet because LANDFIRE provides all metrics needed for carbon stock calculations, whereas NLCD only provides vegetation type. **Refer to the data evaluation memorandum, submitted May 2022, for additional information**. Examples of the LANDFIRE vegetation type discrepancies are depicted in Figure 2, below.

Stakeholder review of the land cover classification identified additional areas, mainly pasture and hay, barren, and wetlands that were incorrectly classified.[15] The areas identified were cross-checked with satellite imagery and updated to reflect the appropriate land cover type.

[15] Misclassified areas identified by Abigail Fateman, Executive Director of East Contra Costa County Habitat Conservancy, Kamyar Aram, Specialty Crops Advisor with University of California Cooperative Extension, and Ben Weise, Agriculture Conservation Manager with Contra Costa Resource Conservation District (April 2022).

Figure 2 LANDFIRE Inaccuracies (2001 and 2021)

Imagery provided by Esri and its Licensors, 2022.

Methods and Findings

Following a consistent methodology for land cover classification, carbon inventories, and baseline projections allow for reproducible updates and comparison of carbon stock and emissions over time based on land cover. Where possible, the inventories are based on regional datasets that are updated over time and provide a consistent approach. However, the scale of carbon sequestering management activities often does not result in land cover change, and therefore is not captured in the inventories. Capturing smaller scale changes in carbon stock and emissions requires a monitoring approach that modifies estimates in places where activities that change carbon stock and emissions have been applied. The Contra Costa County carbon inventories methodology is based on the Resilient Merced pilot project. The first step includes estimating carbon stocks by land cover class (i.e., forest, grassland, shrub,.) for 2001 and 2021 using LANDFIRE and NLCD datasets described in the Data Sources section and the data evaluation memorandum. The second step involves calculating carbon stored in different carbon pools (i.e., above- and below-ground live biomass, litter, soil,.) based on existing vegetation type, cover, and height. This step illustrates changes in carbon stock as a result of land cover changes between 2001 and 2021. The sections below describe the methodology and findings of the two components of the analysis: the carbon inventories, and the baseline projections.

Carbon Inventories

Land Cover Classification

This analysis was conducted using 30-meter cell resolution across the County for 2001 and 2021. For each inventory year, the Existing Vegetation Type LANDFIRE and NLCD datasets were used to determine the land cover classes across all land in the County. The land-cover classes assigned in the 2001 and 2021 are:

- Barren – areas where vegetation accounts for less than 15 percent of total cover, for example areas of bedrock, sand dunes, or gravel pits.
- Cultivated and Field Crops – areas used for the production of vegetables and field crops generally grown for human consumption, such as corn, soybeans, and wheat.
- Development – areas with constructed materials, including buildings and roads.
- Forest – areas dominated by trees with more than 10 percent tree cover.[16]
- Grassland/Herbaceous – areas dominated by herbaceous vegetation, with more than 10 percent herb cover, less than 10 percent tree cover and less than 10 percent shrub cover.
- Open Water – areas of water with less than 25 percent cover of vegetation or soil.
- Orchard – areas used for the production of fruits and nuts.
- Pasture and Hay – areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture or hay accounts for more than 20 percent of total vegetation.
- Shrub/Scrub – areas dominated by shrubs greater than 10 percent of total shrub cover and less than 10 percent tree cover.[17]

[16] Includes riparian areas that are dominated by trees with more than 10 percent tree cover.
[17] Includes riparian areas that are dominated by shrubs greater than 10 percent of total shrub cover and less than 10 percent tree cover.

- Vineyard – areas planted with grapevines, generally used for producing grapes used in winemaking.

See the Quality Assurance and Quality Control (QA/QC) section for an overview of how LANDFIRE classification inaccuracies were identified and resolved. See the data evaluation memorandum for a full description of data and QA/QC methodology. Land Cover Classification Results are summarized in Figure 3, Figure 4, Figure 5, Figure 6, and Figure 7. Between 2001 and 2021 the largest losses in acreage occurred in shrubland and cultivated and field crops. The largest increase in acreage between 2001 and 2021 was in development. As shown in Figure 4, much of the development occurred on former agricultural land (cultivated cropland and pasture and hay) and shrubland indicating a trend of extensive development converting natural and working lands to housing, commercial, and other developed uses. Within city limits, development increased from 65,353 acres to 95,958 between 2001 and 2021 for a total increase in 30,605 acres between the two years. In the unincorporated County, development increased from 19,720 acres to 30,034 acres between the two years for a total increase of approximately 10,314 acres.

Figure 3 Land Cover Maps (2001 & 2021 LANDFIRE)

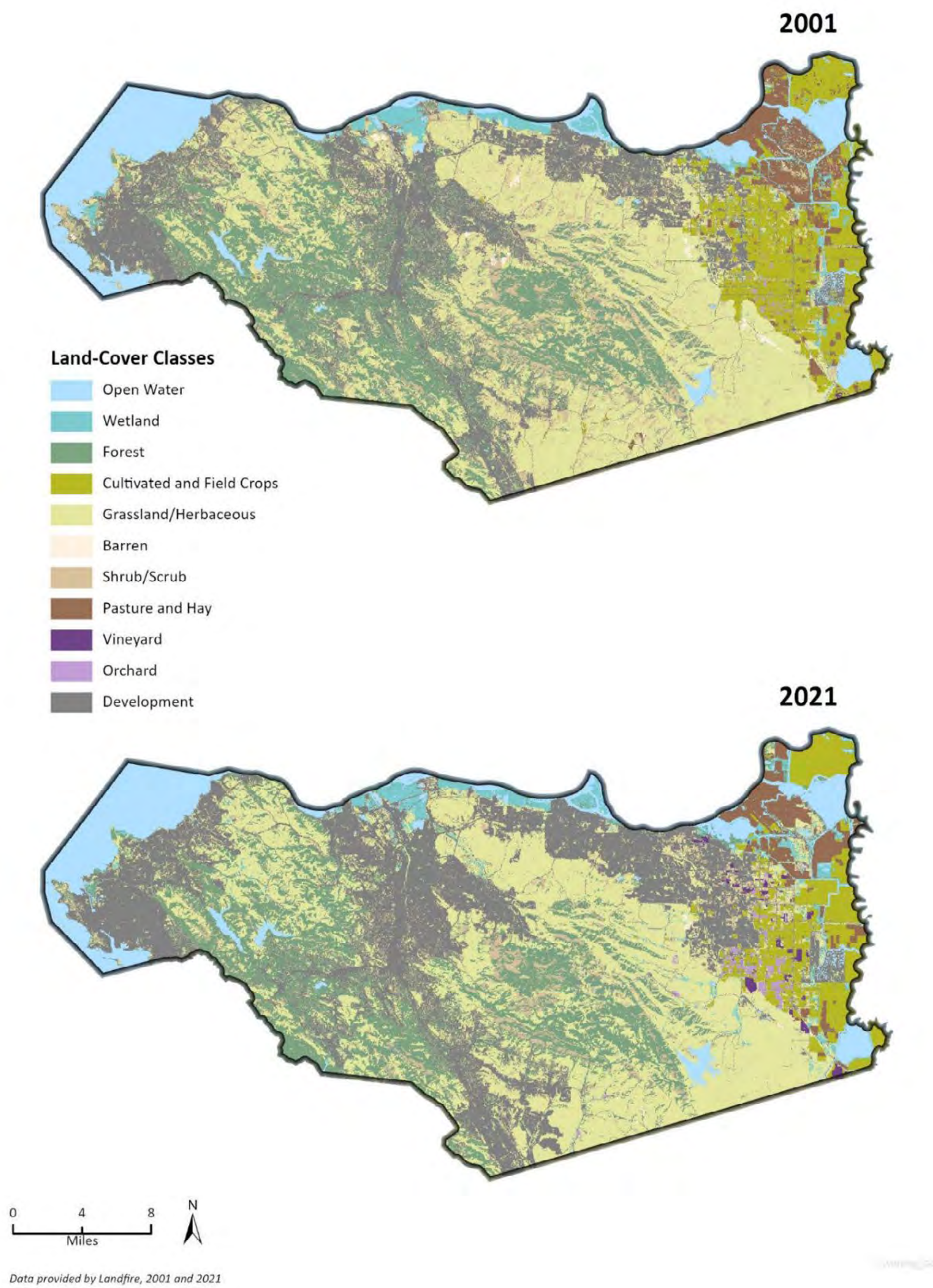
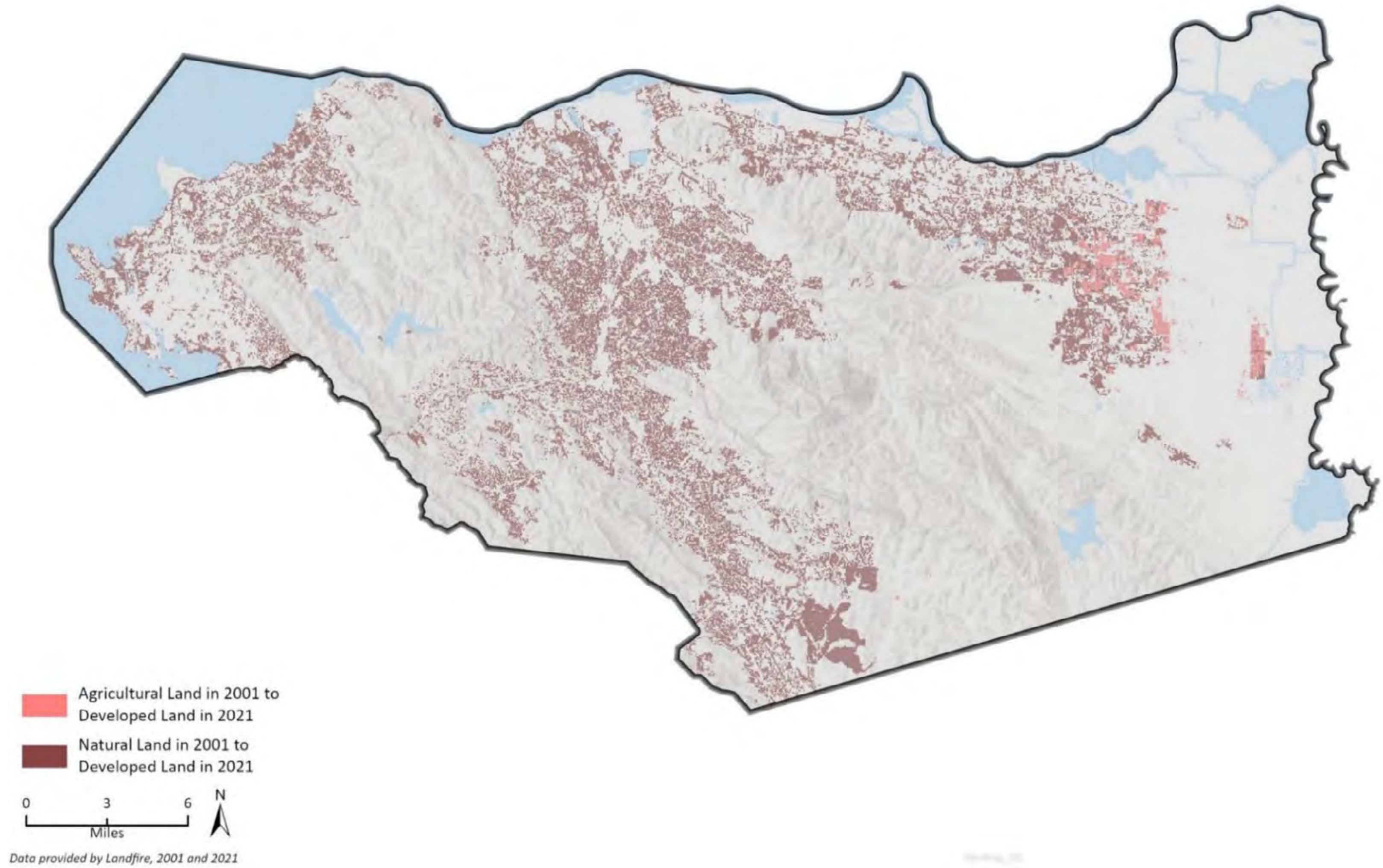


Figure 4 Development Expansion[18]



[18]Agricultural lands include cultivated and field crops, orchard, pasture and hay, vineyard. Natural lands include open water, wetland, forest, grassland/herbaceous, barren, and shrub/scrub.

Figure 5 2001 Land Cover (LANDFIRE)

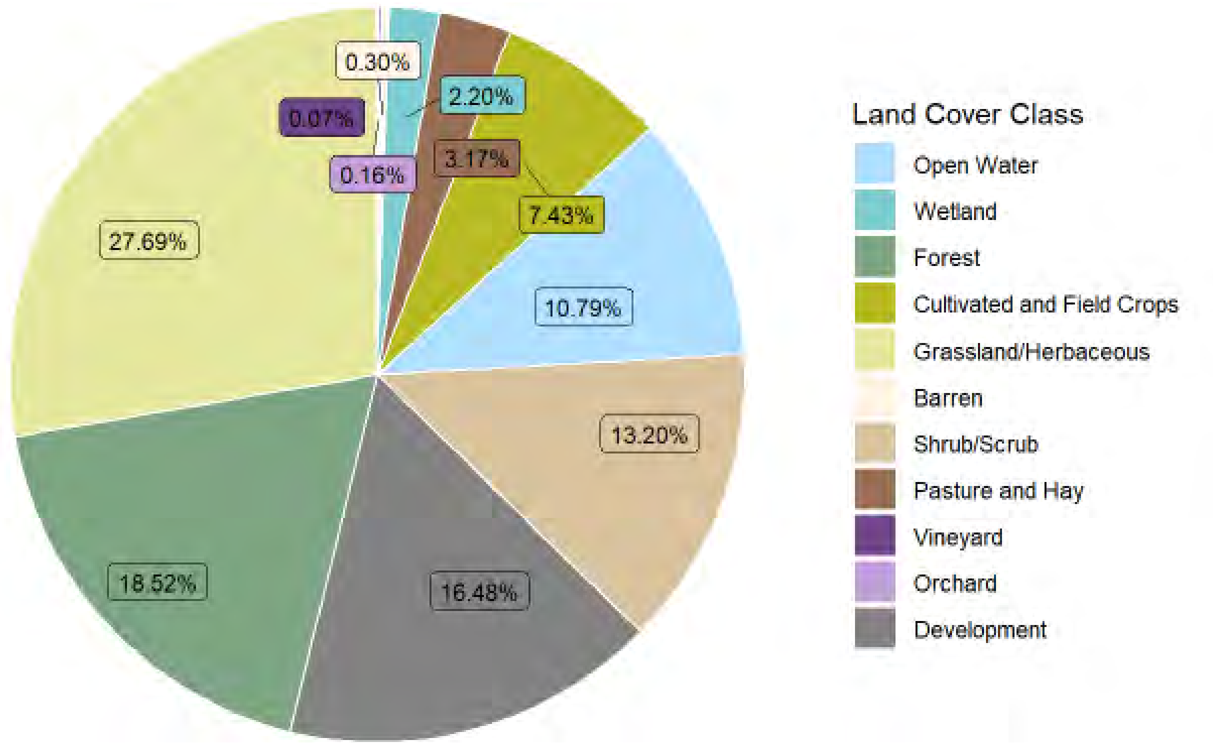


Figure 6 2021 Land Cover (LANDFIRE)

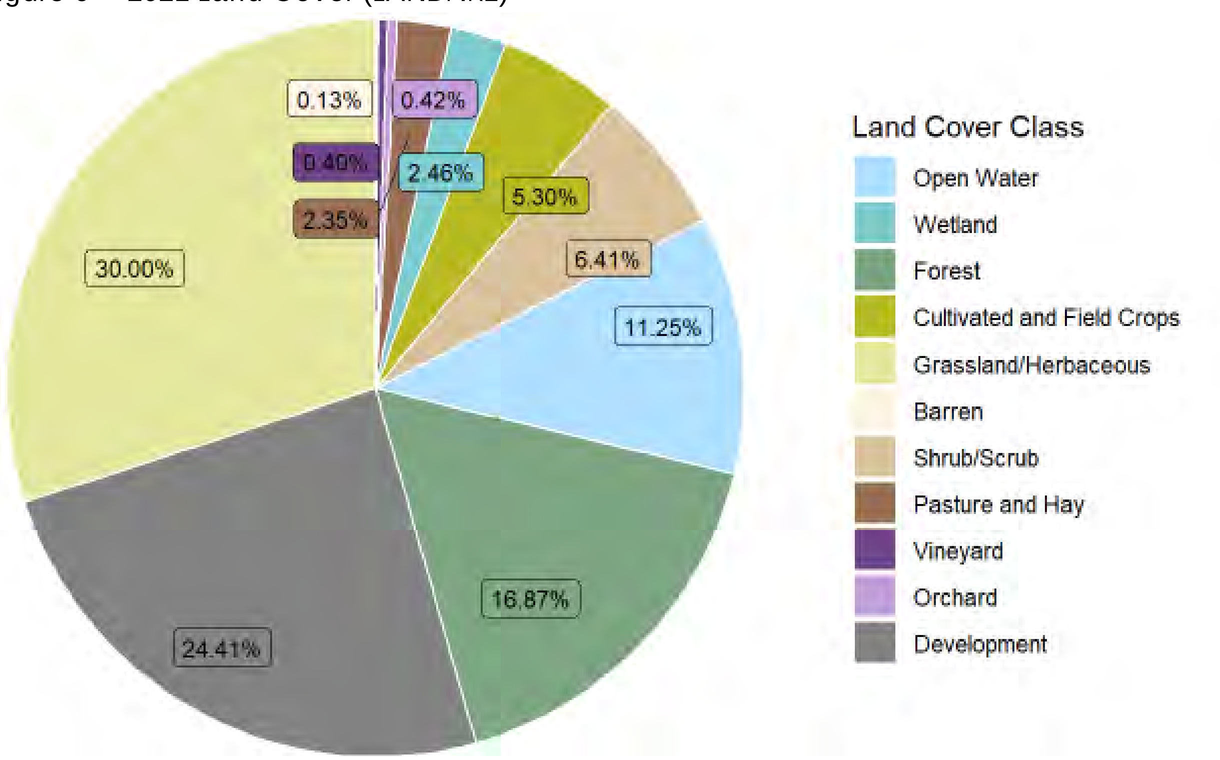


Figure 7 Land Cover Class as Percent of Total Land Area (2001 & 2021 LANDFIRE)

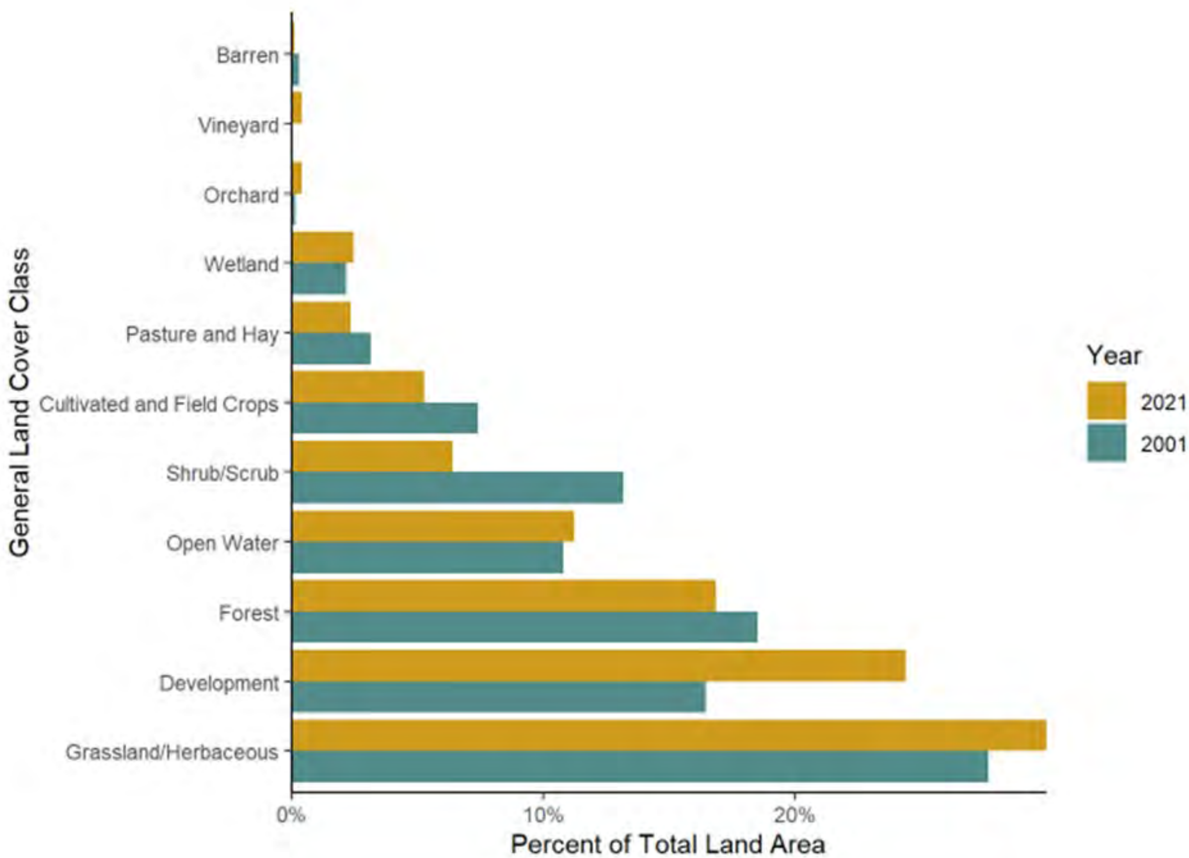


Table 2 below shows the number of acres in each land cover class for 2001 and 2021 and the percent change between the two years.

The data show that between 2001 and 2021, developed land cover increased from about 16% to 24% of total land cover and totaled an estimated 40,921 acres in 2021. During the same period, the area classified as shrubland decreased by 51%, a loss of an estimated 35,052 acres. As is observable in the above land classification maps, much of the development occurred on former cultivated cropland, pasture and hay, and shrubland indicating a trend of extensive development converting natural and working lands to housing, commercial and other developed uses. Figure 4 above shows the areas of urban expansion where lands classified as development in 2021 are highlighted, with the color indicating whether they were classified as agricultural or natural lands in 2001.

The third most substantial change in land cover by acreage after development and shrub land, is the 11,012-acre decrease in cultivated and field crops. This reduction represents a reduction from about 7% to 5% of total land cover between the two reference years (2001 and 2021). While some of the decrease in cultivated and field crop land may be attributed to switching of land from one agricultural use to another, when all agricultural land cover classifications (cultivated and field crops, orchard, pasture and hay, vineyard) are summed for both 2001 and 2021, there is an overall decrease in land classified under agricultural land cover types, which include cultivated and field crops, orchard, pasture and hay, and vineyard. In 2001 there was a total of 55,856 acres of land classified under agricultural uses and by 2021 that decreased by 22% (12,127 acres) to 43,729 acres classified under agricultural uses. This indicates an overall trend of loss of agricultural lands to other uses, such as development.

Table 2 Land Cover Class Acreage (2001 & 2021 LANDFIRE)

Land Cover Class	2001 Acres	2021 Acres
Barren	1,551	697
Cultivated and Field Crops	38,354	27,342
Development	85,072	125,993
Forest	95,607	87,106
Grassland/Herbaceous	142,921	154,839
Open Water	55,688	58,062
Orchard	814	2,162
Pasture and Hay	16,347	12,143
Shrub/Scrub	68,159	33,107
Vineyard	341	2,060
Wetland	11,331	12,677
Total	**516,185**	**516,185**

Notes: Acres have been rounded to the nearest whole number therefore sums may not match.

Land-based Carbon Inventory

The land-based carbon inventory and baseline projection will follow the methodology outlined in Resilient Merced, California's 2017 Climate Change Scoping Plan, and the State's Natural and Working Lands Inventory.[19,20,21] Refer to the data evaluation memorandum for a complete discussion of the methodology for completing the County's land-based carbon inventories and baseline projection. The inventory of carbon stocks for natural and working lands (land-based carbon inventory) in Contra Costa County covers the County's 516,185 acres, which includes all natural, agricultural, and urban areas and water.

Carbon Stock Estimates

Carbon stock estimates are based on the sum of carbon stored in different carbon pools. Carbon stock analysis includes carbon stored in the following carbon pools:

- Above- and below-ground live biomass
- Above- and below-ground dead standing trees
- Lying dead wood (e.g., branches, logs, etc. lying on the ground surface)

[19] California Department of Conservation, The Nature Conservancy, Tukman Geospatial, Climate Action Reserve, and Merced County. 2018. Resilient Merced. Available: https://maps.conservation.ca.gov/TerraCount/downloads/. Accessed March 11, 2022.
[20] California Air Resources Board (CARB). 2017. California's 2017 Climate Change Scoping Plan. Available: https://ww2.arb.ca.gov/sites/default/files/classic//cc/scopingplan/scoping_plan_2017.pdf. Accessed March 11, 2022.
[21] CARB. 2018. An Inventory of Ecosystem Carbon in California's Natural and Working Lands. Available: <https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf>. Accessed March 11, 2022.

- Litter (e.g., freshly fallen or slightly decomposed leaves, bark, twigs, flowers, fruits, and other vegetable matter)
- Soil

The tables below summarize the carbon stock estimates for Contra Costa County. Table 3 includes estimates of carbon stored in the various above and below ground pools by land cover class. Table 4 includes the estimated carbon stored in soils by each land cover class.

Above and Below Ground Carbon

Carbon stored in all above- and below-ground biomass (including live, dead, and litter), not including soil carbon, was calculated using volumetric estimates of carbon mass (metric tons per hectare) provided by the California Air Resources Board (CARB) using the methodology described in the data evaluation memorandum.[22]

Table 3 Contra Costa County Above and Below Ground Carbon per Acre (2001 and 2021)

Land cover Class	Average Above and Below Ground Carbon/Acre 2001 (MT CO_2e)	Average Above and Below Ground Carbon/Acre 2021 (MT CO_2e)
Barren	0	0
Cultivated and Field Crops	3	3
Development	24	24
Forest	39	40
Grassland/Herbaceous	2	2
Open Water	0	0
Orchard	7	7
Pasture and Hay	2	3
Shrub/Scrub	20	14
Vineyard	2	2
Wetland	2	2

In Contra Costa County, forests hold the most above and below ground carbon per acre, followed by developed land and shrubland. According to this analysis, the forest land cover class experienced a 3 percent increase in above and below ground carbon storage per acre and the shrub/scrub class experience approximately 30 percent decrease in above and below ground carbon storage per acre. These changes in per acre carbon storage are due to changes in vegetation type (e.g., shrub to development), height, and/or percent cover between the two years, provided by LANDFIRE. All other land cover classes maintained the same amount of above and below ground carbon storage per acre between 2001 and 2021.

Soil Carbon

Soil carbon values are obtained using the combined NCSS Characterization Database, the National Soil Information System (NASIS), and the Rapid Carbon Assessment (RaCA) datasets described in the data

[22] Volumetric estimates of carbon mass were provided by Klaus I. Scott, Emission Inventory Analysis Section of the Greenhouse Gas & Toxics Emission Inventory Branch, AQPS Division at CARB on November 17, 2020.

evaluation memorandum. The soil carbon inventory estimates are determined by using the values provided for soil organic carbon and soil bulk density at a depth of 0-30 centimeters.[23] Because the soil data used is from a snapshot in time (2017) it does not capture changes in soil carbon over time due to management or land cover change. Future inventories should use updated data which would reflect changes in soil carbon due to management and land cover change.

Table 4 Contra Costa County Soil Carbon per Acre (2001 and 2021)

Land cover Class	Average Soil Carbon/Acre 2001 (MT CO_2e)	Average Soil Carbon/Acre 2021 (MT CO_2e)
Barren	54	62
Cultivated and Field Crops	206	256
Development	58	60
Forest	75	81
Grassland/Herbaceous	55	58
Open Water	9	16
Orchard	98	45
Pasture and Hay	278	327
Shrub/Scrub	68	67
Vineyard	332	38
Wetland	203	175

In Contra Costa County, the largest soil carbon per acre is stored in lands bordering the Sacramento-San Joaquin Delta (Delta). The Delta borders the northern and eastern edges of the County. The soils in the Delta are some of the richest in the world because they are composed of organic material from decaying plants that accumulated over millennia.[24] In 2001, vineyard, pasture and hay, cultivated and field crops, and wetlands bordered the Delta, and therefore stored the most soil carbon per acre. In 2021, pasture and hay, cultivated and field crops, and wetlands bordered the Delta and therefore held the highest soil carbon per acre. Because the soil carbon data used in this analysis is static, changes in average soil carbon type reflect how much of each land cover type moved on to or off of the organic-rich Delta soils.

Carbon Inventory Totals

The carbon inventory associated with each land cover type, including all above- and below-ground biomass and soil carbon for 2001 and 2021, is mapped in Figure 8 and provided in Table 5 and Table 6 below. All carbon stock values are presented in metric tons of carbon dioxide equivalent (MT CO_2e).

Table 5 shows the average carbon stock for 2001 and 2021, which is the sum of above- and below-ground carbon and soil carbon, per acre for each land cover class in Contra Costa County. Changes in carbon stock are due to changes in land cover type, vegetation type, vegetation height, and percent cover of vegetation, as well as the extent and location of the land cover type. For example, if a land

23 A portion of soil organic carbon is located below 30 centimeters, and management practices that lead to enhanced carbon storage in both shallow and deep soils will be included in the carbon sequestration feasibility assessment for this project.

24 The New Humanitarian. 2017. California's Delta Poised to Become Massive Carbon Bank. Available: <https://deeply.thenewhumanitarian.org/water/community/2017/06/09/californias-delta-poised-to-become-massive-carbon-bank>. Accessed May 13, 2022.

cover type shifted onto the organic-rich Delta soils, it would show a greater carbon stock value. In 2021, pasture land stored the most total carbon per acre followed by lands with cultivated and field crops, and wetlands. Table 6 shows the total carbon stock countywide for each landcover type for 2001 and 2021 and the percent change between the two years. In both 2001 and 2021, forests held the most total carbon in the county. In 2021, the most carbon stored in the county after forests were development, grassland, and cultivated and field crops.

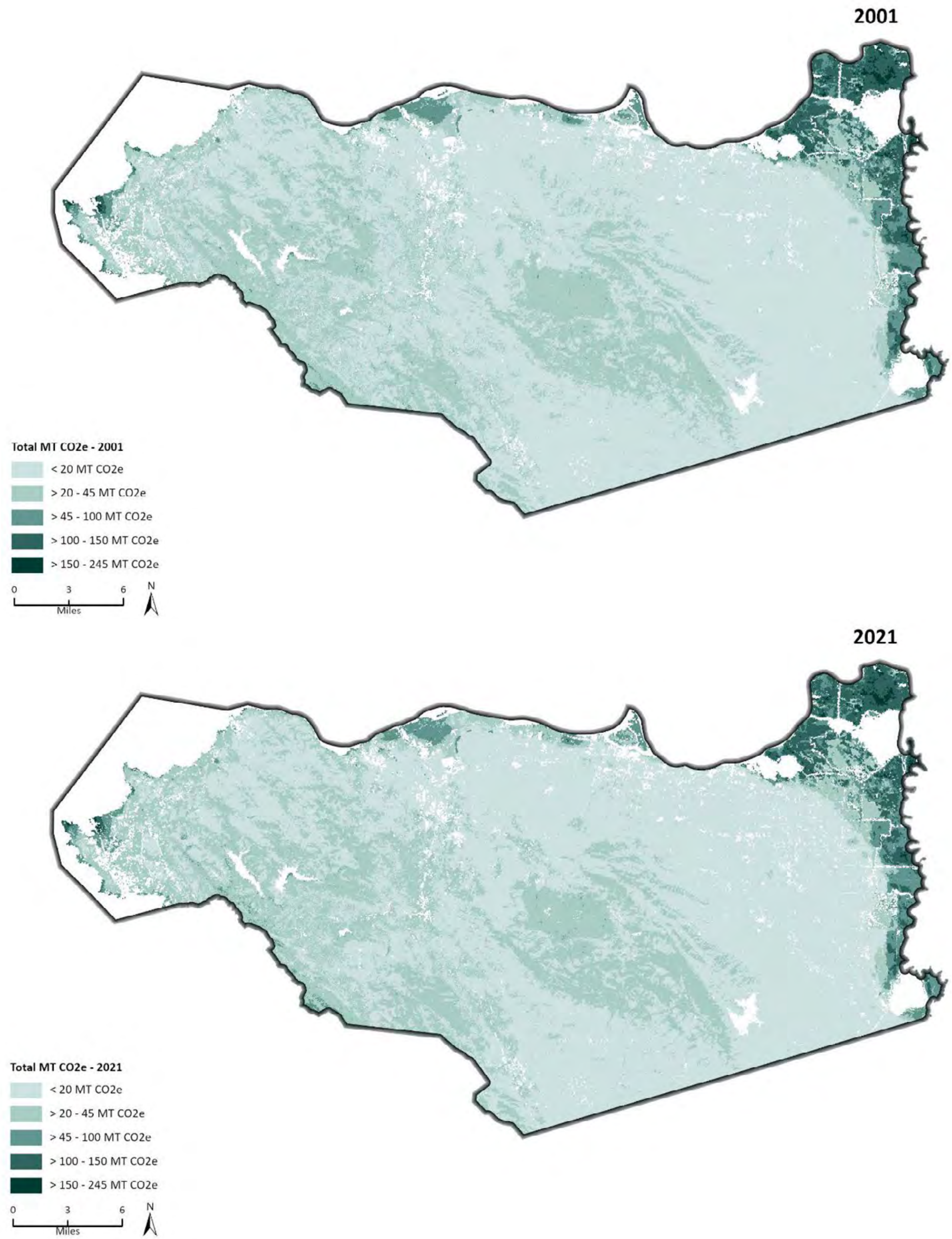
Table 5 Contra Costa County Carbon Stock per Acre (2001 and 2021)

Land Cover Class	Average Carbon Stock per Acre 2001 (MT CO_2e)	Average Carbon Stock per Acre 2021 (MT CO_2e)
Barren	54	62
Cultivated and Field Crops	208	259
Development	86	86
Forest	130	129
Grassland/Herbaceous	57	59
Open Water	10	16
Orchard	106	53
Pasture and Hay	281	330
Shrub/Scrub	95	89
Vineyard	334	40
Wetland	205	175

Table 6 Contra Costa County Total Carbon Stock (2001 and 2021)

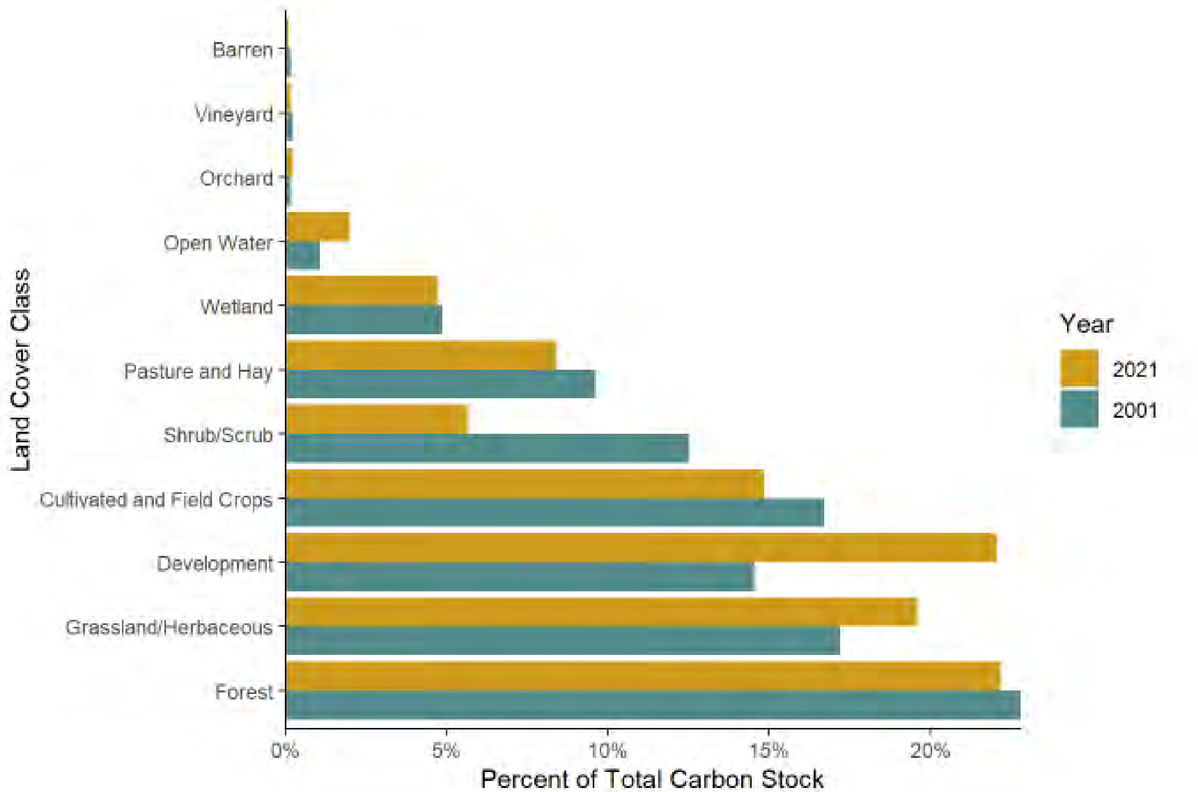
Land Cover Class	Total Carbon Stock 2001 (MT CO_2e)	Total Carbon Stock 2021 (MT CO_2e)	Total Carbon Stock Difference from 2001 to 2021 (MT CO2e)
Barren	84,161	43,503	-40,658
Cultivated and Field Crops	7,986,530	7,077,346	-909,184
Development	6,944,497	10,515,137	3,570,640
Forest	10,885,051	10,567,969	-317,082
Grassland/Herbaceous	8,221,468	9,332,609	1,111,141
Open Water	519,544	946,128	426,584
Orchard	86,133	113,773	27,640
Pasture and Hay	4,587,815	4,001,492	-586,323
Shrub/Scrub	5,978,461	2,691,498	-3,286,963
Vineyard	113,777	82,157	-31,620
Wetland	2,326,576	2,254,891	-71,685
Total	**47,734,013**	**47,626,503**	**-107,510**

Figure 8 2001 and 2021 Total Carbon Stock



As described and illustrated in the Land Cover Classification section above, development acreage increased, and shrubland decreased, substantially. This change is apparent in the carbon stock values as well. Changes in carbon stock are due not only to changes in vegetation type (e.g., shrub/scrub to grassland) but also vegetation height and cover. The shrub/scrub land cover class encompassed approximately 13% of the total land cover area in 2001 and dropped to 6% in 2021. This land cover class carbon stock decreased by 3,286,963 metric tons of CO_2e and went from containing 13% of the County's total carbon stocks in 2001 to only 6% in 2021. From 2001 to 2021, development acreage increased from 16% to 24% of total land cover, and the carbon stock increased from 15% to 22% of the County total due to an increase in carbon stock held in the urban forest. Forests decreased by 9% and grassland increased by 8% between the two years. The grassland carbon stock increased by 14% and forest carbon stock decreased by 3%. The general trend of reduced agricultural land cover is also reflected in the carbon stocks for those land cover classes. The 11% decrease in cultivated and field crop carbon stock, and the 13% decrease in pasture and hayland carbon stocks are the two largest agricultural decreases in carbon stock by metric ton of CO_2e between the two reference years. Figure 9 shows the proportional carbon stock changes between 2001 and 2021 for each land classification.

Figure 9 Contra Costa County Proportional Carbon Stocks



Land-based Emissions

GHG inventories for agriculture, forestry, and land use generally include:

- Changes in soil carbon stocks and woody biomass stocks
- Nitrous oxide emissions from soils (including fertilizers), biomass burning, and drained organic soils
- Methane emissions from wetland, rice cultivation, and biomass burning,
- Carbon dioxide emissions from burning, liming, urea fertilization, and drained organic soils
- Carbon monoxide emissions from biomass burning

Most of these land-based emissions sources are calculated elsewhere, are not applicable for the County, or are excluded due to concern over double counting or a combination of data limitations and lack of consistent methodology at the county scale. A brief explanation of these considerations for each land-based emissions source is included below. For further discussion of the land-based emissions sources included and excluded in the County estimates, please refer to the data evaluation memorandum.

Changes in soil carbon stocks and woody biomass stocks are covered above in the Carbon Stock Estimates section of the 2001 and 2021 land cover GHG inventories. These changes are represented by the change in total carbon stock for a given land cover class and the County as a whole, since the total carbon stock includes both the carbon stored in soil and vegetation. The total carbon stock for the County decreased by 107,510 MT CO_2e between 2001 and 2021 as a result of land-use changes. The biggest losses in carbon stock by land cover type were due to decreases in acreage of shrubland, cultivated cropland, pastureland, and forest. The estimated decrease in total carbon storage is equivalent to the estimated land-based emissions as a result of land use change. The decrease is not included as a land-based emission in summary tables to avoid double counting because it is already captured as the change in total carbon stocks between inventory years.

Biomass burning is not a widespread practice in the County and so nitrous oxide, methane, carbon dioxide, and carbon monoxide emissions related to biomass burning are considered de minimis and omitted from this analysis. Likewise, rice cultivation is extremely limited or entirely absent, and so related emissions are considered de minimis.

Due to a combination of data limitations and a lack of consistent methodology at the county scale, nitrous oxide, and carbon dioxide emissions from drained organic soils, burning, liming, urea fertilization, rice cultivation, and nitrogen fertilizer runoff affecting wetlands are excluded from this analysis. Additionally, emissions associated with fertilizer application for agricultural uses are included in the County's Community GHG Inventory, therefore, including them in this analysis would result in double-counting emissions. Therefore, for the purposes of the Contra Costa County land-based carbon emissions analysis, only methane emissions associated with wetlands will be estimated.

While both land use and land management practices drive land based GHG emissions, temporal data on land management activities is largely unavailable, therefore, changes in GHG emissions estimates from 2001 to 2021 are driven by land use change.

Wetlands Emissions

Emissions from wetlands are estimated for 2001 and 2021, and the difference between those two years provides the baseline reference projection. The area under the wetland land cover class increased by 1,345 acres, a change of 12% between 2001 and 2021. This is assumed to be due to a combination of changes in satellite data underlying the land cover classification for the two baseline years, and to a smaller degree to wetland restoration projects, such as the Lower Walnut Creek Restoration project.

Inundation describes the condition when land is covered with water. Inundation can be either a temporary or permanent condition. The frequency and duration of inundation will affect the development of anaerobic conditions in wetland soils that lead to methane emissions. As a result, methane emissions are higher in continuously inundated wetlands due to increased anaerobic conditions that form when less oxygen is present and emissions are lower in intermittently inundated wetlands due decreased incidence of anaerobic conditions. Continuously inundated wetlands have estimated methane emissions of 16.02 metric tons per hectare per year (carbon dioxide equivalent), while intermittently inundated wetlands have estimated methane emissions of 3.53 metric tons per hectare per year (CO_2e).[25] The wetlands in Contra Costa County were assumed to be 88% intermittently inundated and 12% continuously inundated[26]. Without site-specific hydrological studies it is difficult to estimate a precise percentage of wetland that is continuously or intermittently inundated on an annual basis. Inundation assumptions were made for each wetland land class subtype based on the general characteristics of that wetland subtype classification, a review of satellite imagery, and region-specific sources including the East Contra Costa County Historical Ecological Study. Coastal and tidal marsh systems were assumed to be 75% intermittently inundated, and 25% continuously inundated. The remaining wetland subtypes were assumed to be 100% intermittently inundated. The weighted percentage of inundation period based on the acreage of these wetland subtypes resulted in the 88% intermittent-12% continuous inundation assumption used to generate emissions estimates for both years.

Nitrous oxide (N_2O) emissions from wetlands are very low, absent the input of organic or inorganic nitrogen from runoff.[27] As discussed in the Land-based Emissions section above, N_2O emissions are excluded for Contra Costa County for several reasons including avoiding double counting of fertilizer related emissions that are included in the Community GHG Inventory, limitations on data regarding nitrogen runoff affecting wetlands, and lack of consistent methodology for estimating these emissions at

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[25] 2013 supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. 2013. IPCC. Available: <https://www.ipcc.ch/site/assets/uploads/2018/03/Wetlands_Supplement_Entire_Report.pdf >. (March 17, 2022)

[26] Inundation regime (continuous or intermittent), without site-specific hydrological studies, is difficult to estimate and assumptions are made based on a combination of wetland classification (NatureServe Terrestrial Ecological Classifications, NLCD Class Legend and Descriptions), review of satellite imagery, and region-specific sources that include descriptions of the hydrological characterization of wetlands (East Contra Costa County Historical Ecological Study). All Sources Referenced:

- NatureServe. 2017. International Ecological Classification Standard: Terrestrial Ecological Classifications: Ruderal NVC Groups of the U.S.-CONUS, Hawai'i and Caribbean. November 2017. <https://landfire.gov/documents/LANDFIRE_Ruderal_NVC_Groups_Descriptions_CONUS.pdf (April 2022)>
- NatureServe. 2018. International Ecological Classification Standard: Terrestrial Ecological Classifications: Terrestrial Ecological Systems of CONUS and Puerto Rico on the LANDFIRE Legend. August 2018. https://landfire.gov/documents/LANDFIRE_Ecological_Systems_Descriptions_CONUS.pdf (April 2022)
- Wetlands Subcommittee, Federal Geographic Data Committee and U.S. Fish and Wildlife Service. 2013. Classification of wetlands and deepwater habitats of the United States, FGDC-STD-004-2013, Second Edition. August 2013. https://www.fws.gov/sites/default/files/documents/Classification-of-Wetlands-and-Deepwater-Habitats-of-the-United-States-2013.pdf (April 2022)
- Multi-Resolution Land Characteristics Consortium (MRLC). n.d. National Land Cover Database Class Legend and Description. n.d. https://www.mrlc.gov/data/legends/national-land-cover-database-class-legend-and-description (April 2022)
- CA Dept. of Fish and Game. 2001. California's Living Marine Resources: A Status Report. December 2001. https://nsgl.gso.uri.edu/cuimr/cuimrb01001/cuimrb01001_part19.pdf (April 2022)
- San Francisco Estuary Institute. 2011. East Contra Costa County Historical Ecological Study. November 2011. https://www.sfei.org/sites/default/files/biblio_files/East_Contra_Costa_Historical_Ecology_Study_Final_%28lowres%29_0.pdf (April 2022)

[27] 2013 supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. 2013. IPCC. Available: < https://www.ipcc.ch/site/assets/uploads/2018/03/Wetlands_Supplement_Entire_Report.pdf >. (March 17, 2022)

the county level. Therefore, methane emissions are calculated for wetlands and emissions estimates are converted into and reported as metric tons of carbon dioxide equivalent.

Emissions from wetlands increased by 2,715 metric tons from an estimated 22,874 metric tons in 2001 to an estimated 25,589 metric tons in 2021, due to an increase in wetland acreage.[28] Table 7 below summarizes the carbon stocks and land-based emissions from wetlands. Table 8 provides the conversion factors and emissions factors used to calculate the emissions from wetlands.

Table 7 Contra Costa Wetland Carbon Stock and Emissions

Year	Hectares	Total Carbon Stock ($MT\ CO_2e$)	Above and Below Ground CO2e per Acre ($MT\ CO_2e$)	Soil Carbon per Acre ($MT\ CO_2e$)	Annual Emissions ($MT\ CO_2e$)
2001	4,586	2,326,576	2	203	20,584
2021	5,130	2,254,891	2	175	25,589

Land-based emission from wetlands were calculated using the equations below and the conversion and emissions factors from Table 8:

Convert wetland land cover acreage to hectares (1 acre = 0.40468564 hectares)

Annual CO_2e emissions = (Hectares **x** Intermittent inundation % **x** Intermittent CH_4 Emission Factor) **+** (Hectares **x** Continuous inundation % **x** Continuous CH_4 Emission Factor)

Convert CH_4 emissions from kg to metric tons (1 kg = 0.001 MT)

Convert CH_4 emissions to CO_2e using the IPCC AR5 100-year global warming potential for CH_4 (CH_4 = 28 CO_2e)

Table 8 Conversions and Emissions Factors

Base Unit	Conversion	Rationale	Final Unit
Conversions			
Acres (ac)	0.40468564 * acres	Conversion of acres to hectares	Hectares (ha)
Kilograms (kg)	0.001 * kg	Conversion of kg to MT	Metric tons (MT)
CH_4 emissions	28 * CH_4 emissions	Convert CH_4 emissions to CO_2e using the IPCC Assessment Report 5 100-year global warming potential for CH_4.	CO_2e
Emission Factors			
Intermittent Inundation Wetlands Emissions Factor	126 kg CH_4 ha^{-1} yr^{-1}	From the 2013 supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. 2013. IPCC.	3.53 MT CO_2e ha^{-1} yr^{-1} (Converted to MT CO_2e)
Continuous Inundation Wetlands Emissions Factor	572 kg CH_4 ha^{-1} yr^{-1}	From the 2013 supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. 2013. IPCC.	16.02 MT CO_2e ha^{-1} yr^{-1} (Converted to MT CO_2e)

ha = Hectare
ac = Acre
MT = Metric Ton
kg = Kilogram
yr = Year
CH_4 = Methane
CO_2e = Carbon dioxide equivalent
IPCC = Intergovernmental Panel on Climate Change

28 As previously noted, this analysis does not include changes in soil carbon because the soil data used is static.

Baseline Projections

Results from the carbon inventories are used to project baseline land cover acreage and carbon stock out to 2030 using a linear regression, as outlined in Resilient Merced. This projection is not intended to predict what will happen in the future, but rather provide a business as usual (BAU) baseline scenario in which carbon stocks continue to change at the same rate as they did from 2001 to 2021.

Many factors, including climate change and policy implementation, will determine potential future trends in carbon stock. The year 2030 aligns with the State of California's climate goals and targets and acts as a near-term projection against which land management activities can be implemented, tracked, assessed, and modified to increase carbon stocks in the County.

Projected BAU Land Use

Figure 10, Figure 11 and Figure 12 show the baseline land cover acreage projections. The baseline projections were derived using a linear extrapolation of past trends in landscape carbon stocks. The baseline acreage projections indicate an increase in development and grassland/herbaceous land cover and a decrease in shrub/scrub, cultivated and field crops, pasture and hay land cover. Barren shows a slight decreasing trend and the remaining land cover types show slight increasing trends. The most significant changes in terms of land cover acreage are due to the projected increase in development and decreases in shrubland and cultivated and field crops.

Figure 10 Projected Acres of Natural and Working Lands by LANDFIRE Land Cover Class

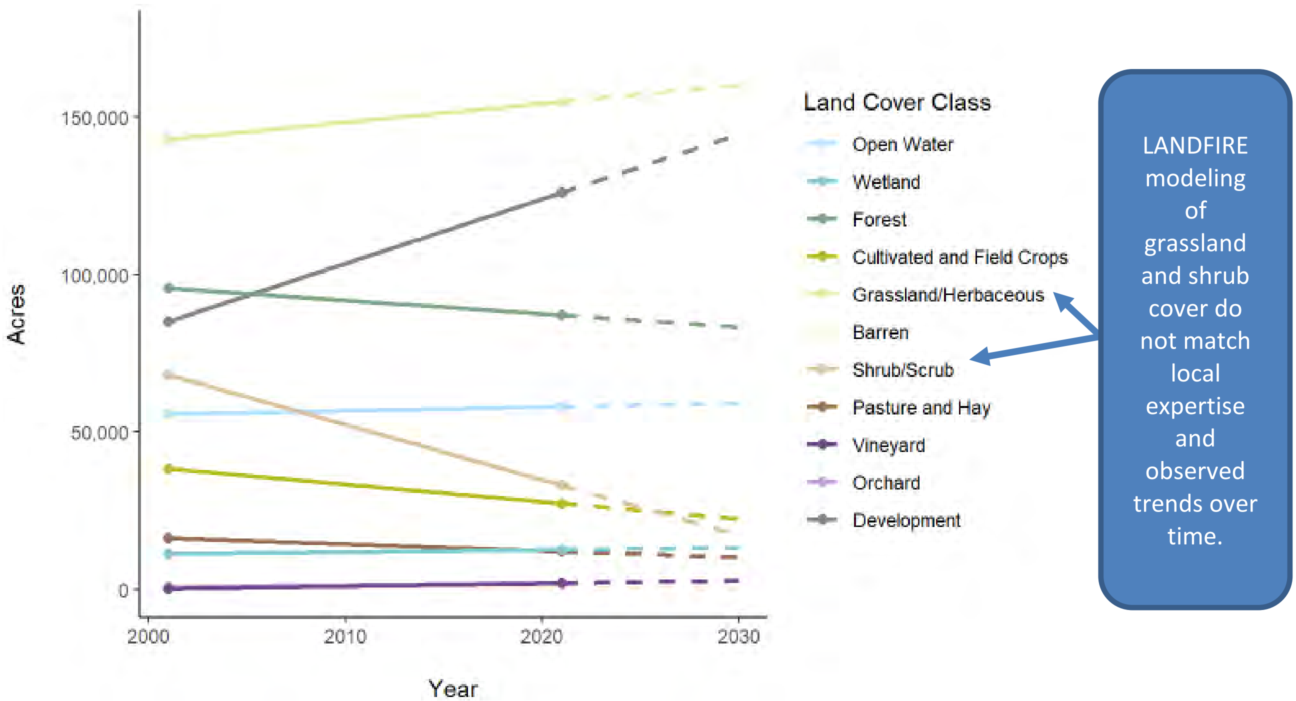


Figure 11 Projected Acres of Natural Lands by LANDFIRE Land Cover Class

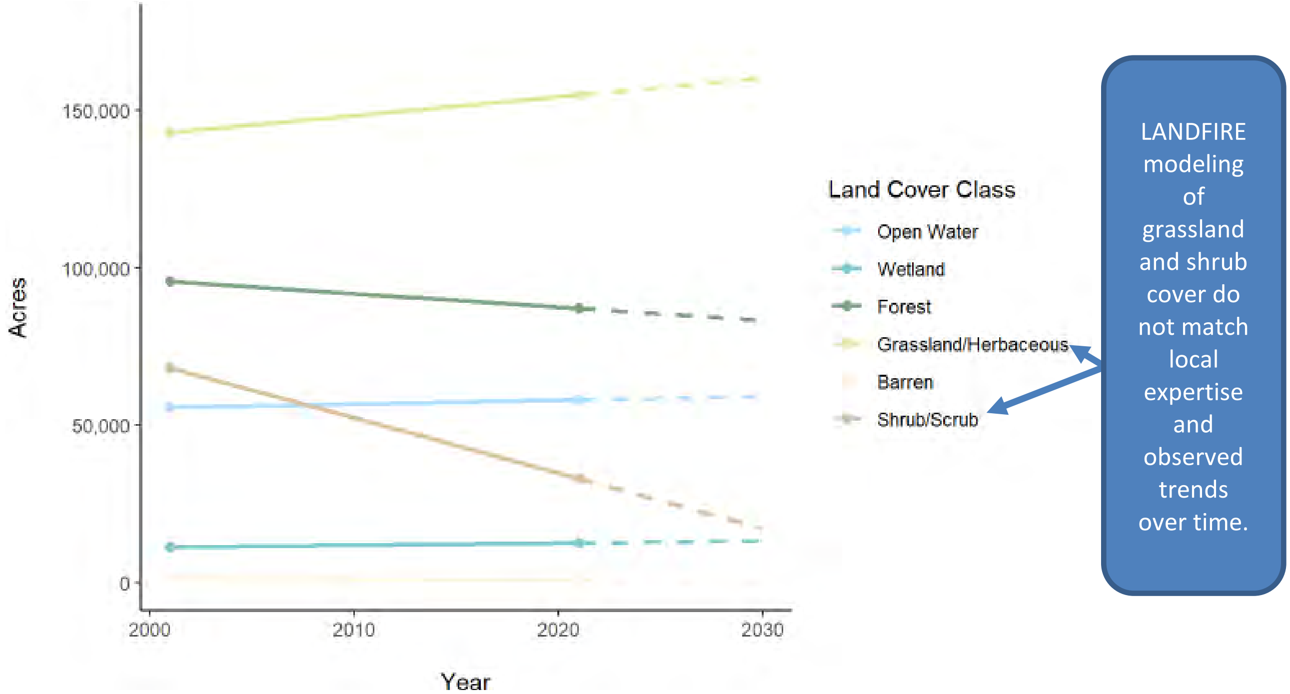
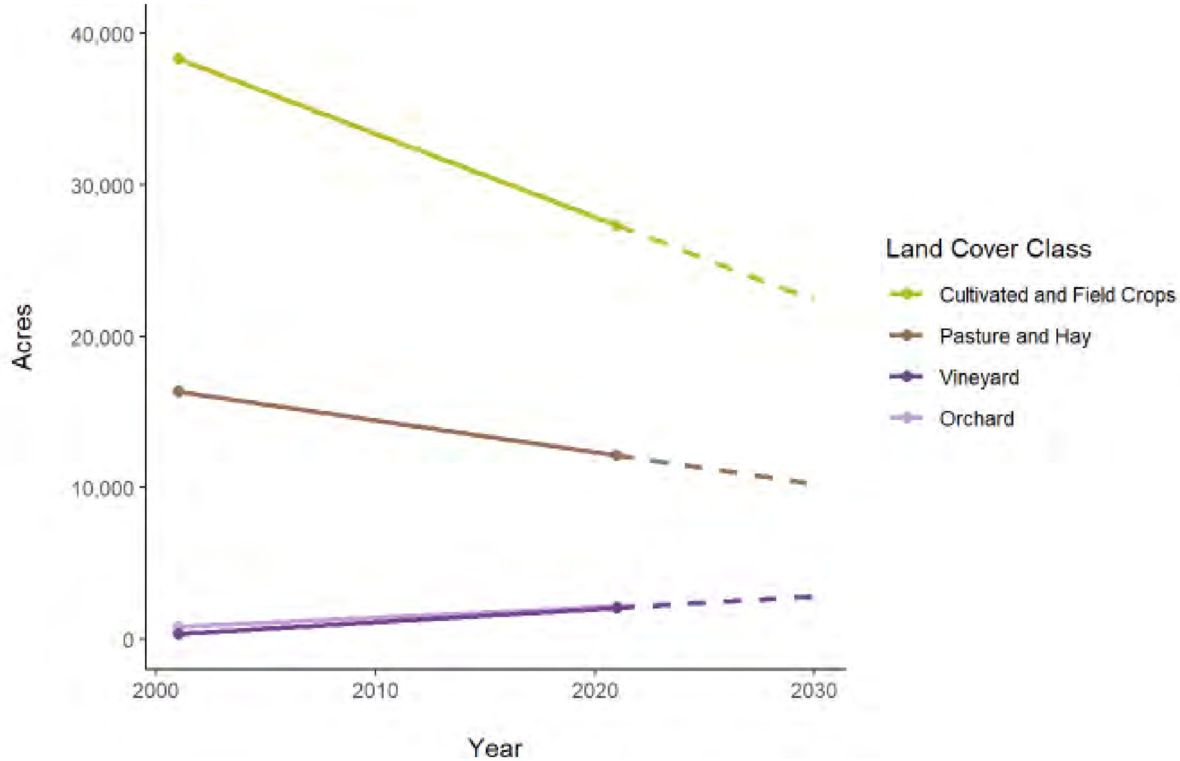


Figure 12 Projected Acres of Working Lands by LANDFIRE Land Cover Class



Projected BAU Carbon Stocks

Figure 13, Figure 14 and Figure 15 show the baseline carbon stock projections for the County's natural and working lands. The baseline carbon stock projections shown below indicate a substantial decrease in shrubland carbon stock projections over time, indicating a replacement of shrubland largely with development as natural lands are converted to housing and other land uses following historical development trends under the baseline scenario.

Total carbon stocks (CO_2e) declined slightly from an estimated 47,734,013 metric tons in 2001 to 47,626,503 metric tons in 2021 which, projected to 2030, will be further reduced to approximately 46,440,034 metric tons based on current trends. The majority of this decline in carbon stocks is due to losses in shrubland carbon. Figure 13, Figure 14, and Figure 15 show the baseline trend in total carbon storage between 2001 and 2030, with the 2001-2021 baseline projected out to 2030. As previously mentioned, changes in carbon stock for a land cover class is due to changes in the spatial distribution of the land cover, vegetation height, and percent cover. Changes in soil carbon are not captured because the soil carbon data that is used in this assessment is static.

Figure 13 Projected Carbon Stock of Natural and Working Lands by Land Cover Class

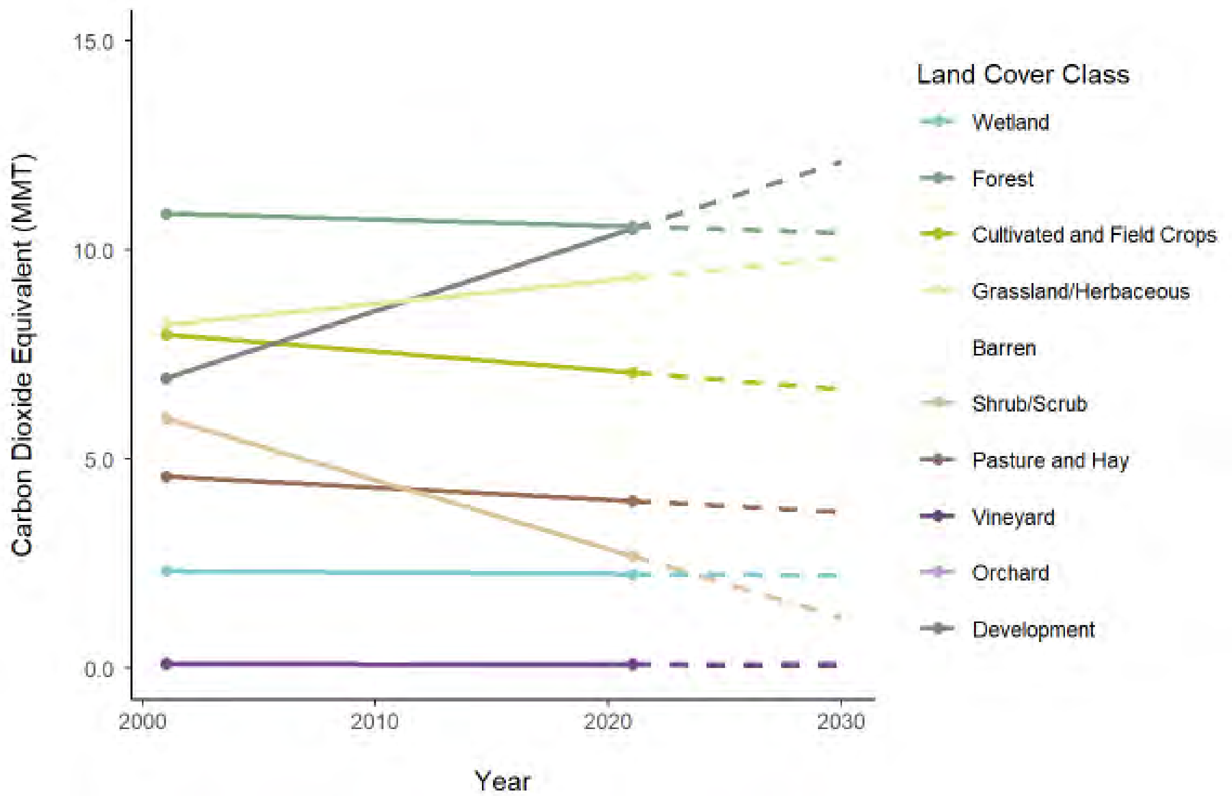


Figure 14 Projected Carbon Stock of Agricultural Working Lands by Land Cover Class

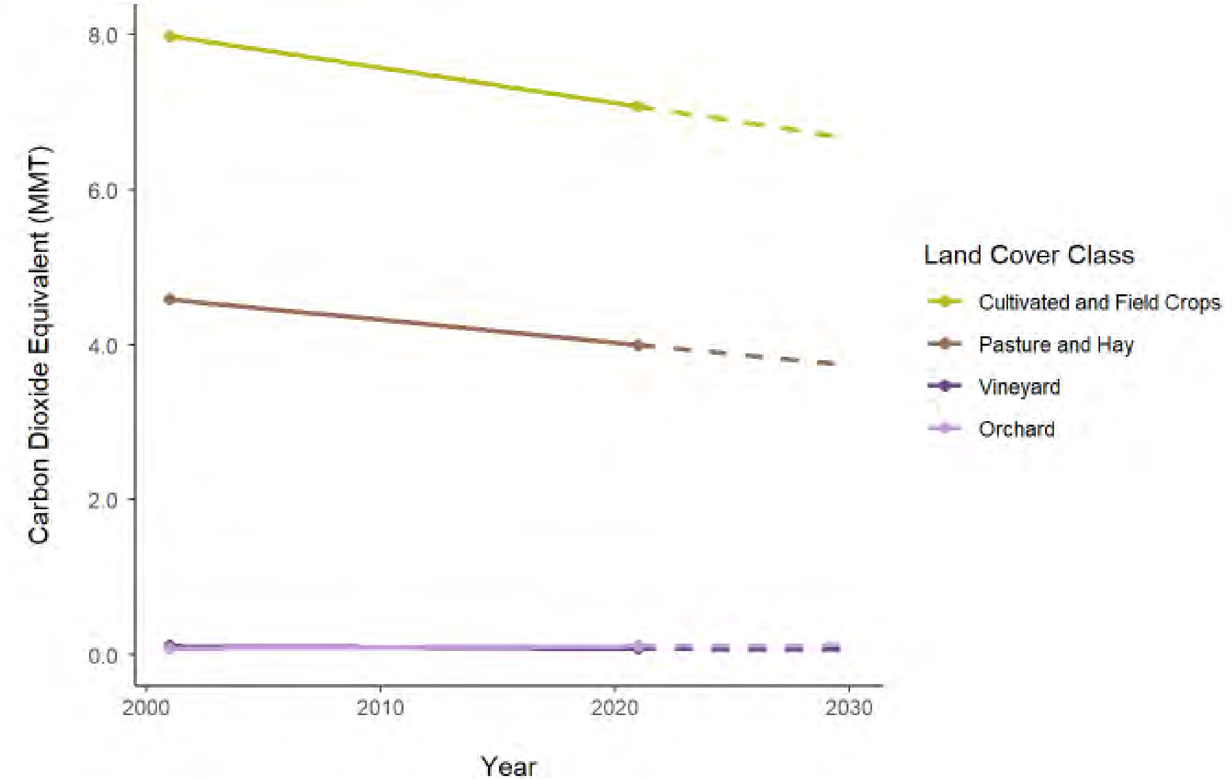
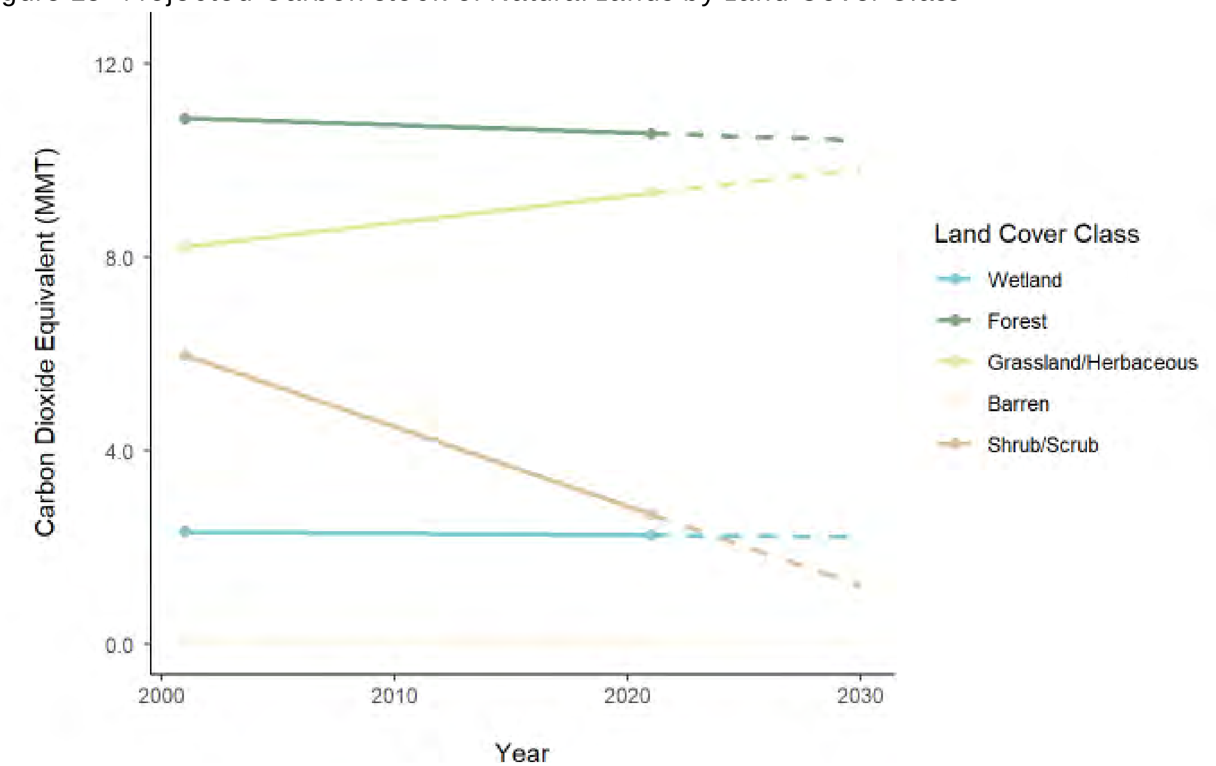


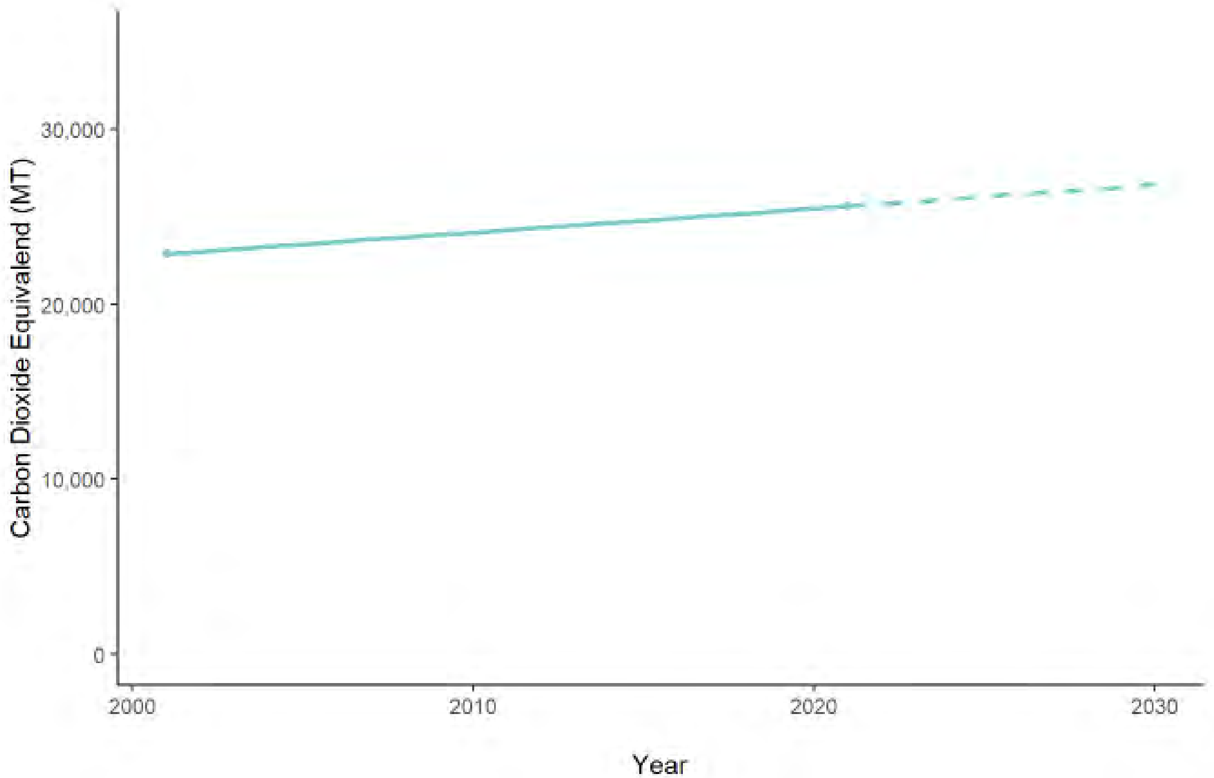
Figure 15 Projected Carbon Stock of Natural Lands by Land Cover Class



Projected BAU Emissions

Figure 16 shows the predicted land-based emissions from wetlands under the baseline scenario. Wetland emissions are shown to increase, this is due to the predicted increase in wetland acreage for the predicted period up to 2030. Annual emissions (CO_2e) increased from an estimated 20,587 metric tons in 2001 to 27,992 metric tons in 2021. Projected to 2030, emissions will be further increased to approximately 31,327 metric tons based on a linear projection of the baseline trend.

Figure 16 Projected Wetland Emissions



Additional Stakeholder Feedback and Conflicting Study Results

While an extensive QA/QC process was conducted with multiple stakeholders of the LANDFIRE datasets, the results of the landcover trend analysis are not consistent with trends seen on the ground by experts in Contra Costa County. And due to the size of the dataset, it is unfeasible to QA/QC every parcel within Contra Costa County. Consequently, additional revisions to the dataset were not made since they may not have provided different results. Therefore, changes in LANDFIRE classification between years, including misclassifications that remain after QA/QC in one of the two baseline years (2001 and 2021), may create false trends in land cover change over time. After the analysis for the feasibility study was complete, trends in grassland and shrubland land cover were questioned by stakeholders with local knowledge of land use change. For example, by using the LANDFIRE Map Viewer, attachment 2881 was assessed to spot check the land cover classification accuracy for the two baseline years against satellite imagery of the site. LANDFIRE classified this site as Southern California Coastal Shrub in 2001, but classifies it as grassland in 2021. This would indicate that shrubland has been lost to grassland over the baseline assessment period. Figure 17 shows the site in 2002, and Figure 18 shows the site in 2022. It is clear from the satellite imagery that the area should have been classified as grassland in 2001.

Figure 17 Satellite Imagery of Contra Costa County Sample Site in 2002

Figure 18 Satellite Imagery of Contra Costa County Sample Site in 2022

The new housing development seen in Figure 18 takes up roughly 20-acres. In order to reflect this, LANDFIRE should classify this area as a 70-acre grassland that became a 20-acre development and 50-acre grassland, rather than a 70-acre shrubland that was reduced to a 50-acre grassland and 20-acre development. This is an example of the small-scale inaccuracies in LANDFIRE classification that can create false trends when two baseline years are compared at the landscape level.

Additionally, the results from the LANDFIRE analysis for changes in grassland and shrubland was counter to the prevailing experience of local stakeholders, and alternative reports tracking land use change. Experts from both the UCCE and RCD with local knowledge of Contra Costa County agricultural land use and trends expressed that the consensus experience and observations from many ranchers, farmers, and land managers is that decreases in grazing pressure and fire suppression have resulted in loss of grassland to shrubland, and not the reverse. Furthermore, local experience is that development is more likely to occur on grassland than on shrubland. Therefore, local knowledge and experience would indicate that land cover trends should show decreases in grassland and rangelands over time, and that shifts from shrub to grass are unlikely outside of fire perimeters or land clearing activities. There is at least one research study that also supports this understanding of land cover changes.

A study conducted in 2003 looked at seven sites throughout the rangelands of San Francisco Bay Area, using aerial photography of each site from previous years to assess changes in vegetation over time. The study confirmed that fire suppression and reduced grazing pressure had resulted in increases of shrubs on lands previously dominated by grasses[29].

While rangelands include multiple land dover types (grassland, forest (oak savannah and oak woodland), shrubland, etc), trends in rangeland can provide supportive evidence for expected trends in grassland. The California Department of Conservation tracks data for important farmland, including for Contra Costa County, through the Farmland Mapping and Monitoring Program. A table summarizing historic land use conversion or important farmland landcover types[30] indicates that in 2000 there were 172,924 acres of grazing land (which may be comprised of multiple land cover classifications in addition to grassland) and 157,424 acres of grazing land in 2018 (the most recent year for which data were available). This data indicates a decline in grazing land of 15,500 acres during that 18-year time span, which would likely include a large proportion of grassland. The Contra Costa County Agricultural Department prepares annual crop and livestock reports. The oldest and most recent crop reports available through the County website were for 2013 and 2019, and those reports include year over year comparisons, so the 2013 report includes 2012 crop data. Comparisons of irrigated pasture and non-irrigated rangelands acreages from those two years also indicate a trend of reduced rangeland acreages, while irrigated pasture remained constant. In 2012 there was approximately 5,450 acres of irrigated pasture and 169,000 acres of rangeland pasture. In 2019, there was still 5,450 acres of irrigated pasture but 149,000 acres of rangeland pasture, a decrease of 20,000 acres of rangeland. While neither of these reports are exclusively applicable to changes in grassland, the findings in combination with local expertise and the study mentioned previously, would suggest that grassland acreage is decreasing over time.

LANDFIRE data is currently used at the national level, and state level, and has been used in similar carbon feasibility assessments for other counties including Merced and Santa Barbara Counties. LANDFIRE data is intended for use in regional land use planning including for carbon sequestration assessments. Given the available data sources, and regular updates to the datasets, LANDFIRE data was considered the best available base data set for this analysis and was updated with additional data sets and corrections were made during the QA/QC process. However, some inaccuracies with classification still remained in the final assessment. These discrepancies run counter to the prevailing knowledge and local experience. Cattle are the top agricultural product by economic value in Contra Costa County, and the concerns raised with the trends in grassland and shrubland may distract from the overall analysis identifying opportunities for improved land management and potential carbon sequestration across the county. Given these ongoing concerns, the County has decided to use the 2021 land cover analysis as the single baseline year for the final report. The land cover analysis for both years and the baseline trends and forecast analysis will remain in this technical memo serving as an appendix to the feasibility report.

While the data and tools used were the best available at the time of this study, there may be new local-scale data products available for future analyses that would further refine the results and allow for more tailored land management recommendations. Specifically, CAL FIRE and East Bay Regional Parks District are currently undertaking a Landscape and Fuels Mapping Project for Alameda and Contra Costa

[29] William H. Russell, Joe R. McBride, Landscape scale vegetation-type conversion and fire hazard in the San Francisco bay area open spaces, Landscape and Urban Planning, Volume 64, Issue 4, 2003, Pages 201-208, https://doi.org/10.1016/S0169-2046(02)00233-5

[30] Important farmland landcover types differ from the landcover classification used by LANDFIRE and other data sources referenced in this memo.

Counties that will produce new datasets that have a resolution of 1-meter for canopy density and height, and 20-meter for ladder fuels. These are finer resolutions than the 30 by 30-meter areas used for this study. In particular the fine scale vegetation and fine scale grassland maps that will be produced as part of this effort can be used in future LANDFIRE QA/QC processes to refine land cover classification. One drawback of this approach is that the time (over two years) and funds (nearly three million dollars) required to produce the fine scale vegetation maps and wildfire risk products and tools, means that it is unlikely that there will be regular updates to these maps at the regional scale. As such, they will be best used for future QA/QC of LANDFIRE data, wildfire mitigation planning, and as a more refined starting place for identifying potential vegetation type-dependent project areas in combination with local expertise and ground truthing. Fine scale vegetation map deliverables will become available from late 2023 through 2025.

Conclusion and Next Steps

This memorandum provides an overview of the data used for the land classification analysis, the results for the County's 2001 and 2021 land classification analysis, a summary of the methodology, the results for the land-based carbon inventories and baseline projections, and the limitation of the data and results.

The carbon inventories provide a quantitative estimate of historical and existing carbon stored in the County's lands. They provide estimates of carbon stock, carbon stock changes, land-based emissions and the resulting GHG flux in the landscape. Carbon stock changes result from disturbances, both human-induced (e.g., conversion of natural lands to development) and natural (e.g., wildfire). Together, the carbon inventories and baseline reference projections were intended to assist tracking how changes in land cover affect carbon stocks and GHG emissions, thereby informing how the County's land base contributes to local and State carbon goals. However, due to errors in the underlying LANDFIRE data set for land classification, in particular for the grassland and shrub/scrub land cover, the baseline projections were not deemed to be useful as a benchmark for changing land use policy. Instead, the 2021 land cover class and carbon stocks are going to set the baseline condition for future analyses and comparison. The results of the original baseline projections using both 2001 and 2021 data interpolated through 2030, is provided for informational purposes only and does not represent the business-as-usual condition for the County against which management activities developed for the County's Carbon Sequestration Feasibility Study should be assessed in the future. Table 9 summarizes the changes in land use and carbon storage and emissions across the two baseline inventory years, 2001 and 2021.

Table 9 Summary of Changes between 2001 and 2021 based on LANDFIRE Data

Land Cover Class	Difference in Acreage	Difference in Total MT CO_2e	Difference in Above and Below Ground MT CO_2e/Acre	Difference in Soil MT CO_2e/Acre	Difference in MT CO_2e Emission
Barren	-854	-40,658	0	8	-
Cultivated and Field Crops	-11,012	-909,184	0	50	-
Development	40,921	3,570,640	0	2	-
Forest	-8,501	-317,082	1	6	-
Grassland/Herbaceous	11,918	1,111,141	0	3	-
Open Water	2,374	426,584	0	7	-
Orchard	1,348	27,640	0	-53	-
Pasture and Hay	-4,204	-586,323	1	49	-
Shrub/Scrub	-35,052	-3,286,963	-6	-1	-
Vineyard	1,719	-31,620	0	-294	-
Wetland	1,346	-71,685	0	-28	2,715
Total	**0**	**-534,094**	**-**	**-**	**2,715**

Understanding how future carbon stocks may change helps to prioritize management activities that can sequester more carbon in areas of interest. For example, the projected decreases in shrub/scrub carbon stock may indicate an opportunity to focus on restoration-related management activities on those lands. TerraCount is a scenario analysis tool which was piloted for the Resilient Merced project, to develop scenarios of change in land use and land management, and evaluate future impacts on carbon stocks. The tool was developed by the Department of Conservation and The Nature Conservancy. Recently, it was determined by the Department of Conservation that TerraCount could not run for counties other than Merced County without substantial customizations, including modifications to the code base. The carbon sequestration potential and complementary benefits analysis for Contra Costa County will be completed outside of the TerraCount model following the TerraCount methodology provided in the TerraCount activity sheets, which detail equations for calculating carbon sequestration potential and a qualitative assessment for complementary benefits.[31]

Consistent with Resilient Merced, Table 10 lists complementary benefits provided by natural and working lands that may be assessed.[32]

The following land management activities were assessed as part of the Resilient Merced project. These practices may be assessed to help develop and prioritize policies to prevent future loss of carbon stocks and increase carbon sequestration:

- Oak woodland restoration
- Cover crops

[31] The TerraCount model will not be run for Contra Costa as it is not set up to be transferrable to counties other than Merced County without substantial modifications to the code base. Instead, TerraCount activity sheets will be used to calculate carbons sequestration potential. TerraCount. N.d. Appendix L Activity Sheets. Available: <https://maps.conservation.ca.gov/TerraCount/downloads/>. Accessed May 9, 2022.
[32] This is not a comprehensive list of complementary benefits of natural and working lands, but rather represents benefit categories for which reliable data sets are available.

- Mulching
- Riparian restoration
- Urban forestry
- Hedgerow planting
- Avoided conversion to croplands
- Avoided conversion to urban
- Compost application to grasslands
- Native grassland restoration.

Table 10 Complementary Benefits

Agricultural	Water	Human Well-being	Biodiversity	Resilience
Agricultural land quality	Agricultural and urban water use	Flood risk reduction	Terrestrial connectivity	Flood risk attenuation
Crop value	Groundwater recharge	Air quality	Natural habitat area	Groundwater banking potential
	Water quality	Scenic value (land use changes in highly visible areas)	Conservation priority areas	Habitat stability
	Watershed integrity		Terrestrial habitat value	Climate connectivity
			Aquatic biodiversity	

Upon review of this memorandum and approval from the County, Rincon will begin refining and assessing land management and carbon sequestration strategies in consultation with the County, University of California Cooperative Extension, Contra Costa Resource Conservation District, and Carbon Cycle Institute. Results from outreach efforts and the survey developed by the University of California Cooperative Extension will be used to refine land management and carbon sequestration strategies to be assessed. Please let us know if you have any questions, comments or concerns with results described in the County's land-based carbon inventories and baseline projections.

Sincerely,
Rincon Consultants, Inc.

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Erik Feldman, MS, LEED AP
Principal

Appendix F

Contra Costa County Carbon Sequestration Potential on Agricultural Lands

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Contra Costa County Carbon Sequestration Potential on Agricultural Lands

A Report to Healthy Lands, Healthy People Carbon Sequestration Feasibility Study

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Contra Costa Resource Conservation District

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Patricia Hickey
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Executive Summary

In 2021, the Contra Costa County Department of Conservation began the Healthy Lands, Healthy People project that aimed to look at land uses within Contra Costa County and identify carbon sequestration opportunities within those lands. As part of that project, Rincon Consultants was hired to lead the analysis and the project. Further, Contra Costa RCD was included to support Rincon's work by specifically focusing on the sequestration potential within Contra Costa County Agricultural Lands. Contra Costa RCD began this study in Summer 2021 with the Carbon Cycle Institute who had delivered similar products in San Mateo and Santa Clara Counties.

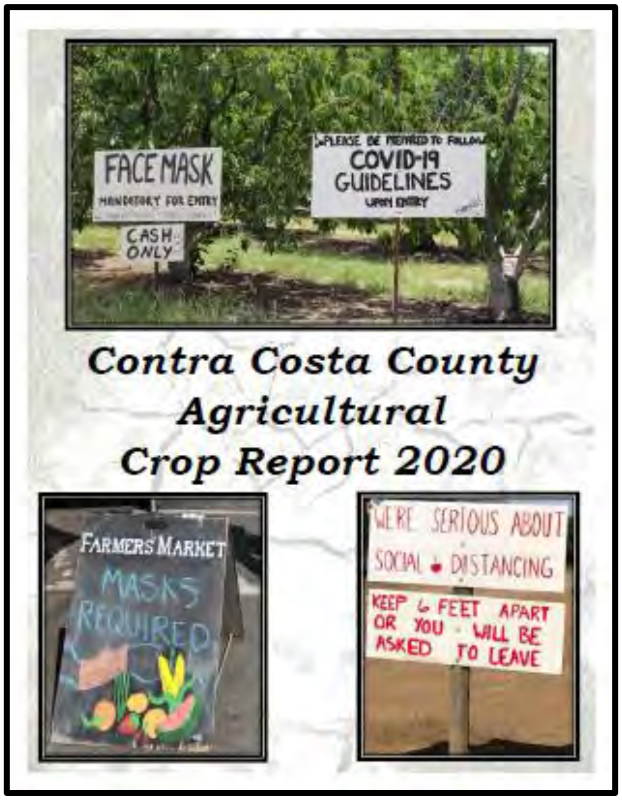

Figure 1. Cover of the 2020 Contra Costa County Agricultural Crop Report courtesy of the Contra Costa County Department of Agriculture, Weights, and Measures

This modeling effort is loosely based off the Carbon Farm Planning (Carbon Cycle Institute, 2023) process that works with individual farms and ranches to determine suitable management practices that address natural resource concerns while also sequestering carbon dioxide. Rather than analyze every individual agricultural parcel, the project team classified agricultural land into four primary crop types: 1) row crop systems that include annual vegetable and seed crops like corn, tomatoes, garlic, and grains, 2) orchard and vineyard systems that include fruit and nut trees and orchards, 3) rangeland systems that support livestock grazing, and 4) urban farms, school, and community gardens. Acreages for each classification were determined through estimation (Urban farms) or based on available data (LANDFIRE, County Agricultural Reports).

With acreages determined, the project team then set about to determine suitable management practices that could be broadly applied across entire cropping systems. Through a combination of historical government data (US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) Application Data, California Department of Food and Agriculture (CDFA) Healthy Soils Program Application Data), interviews with agricultural producers, and technical assistance provider knowledge, a suite of management practices was selected (see Appendix 3). With management practices selected, the project team then needed to determine implementation acreage of each practice. Implementation acreage differs from cultivated or total farm acreage, and is often a small proportion of the total acreage. Cover crop acreage, for instance was calculated based on 70% of an orchard size as they are used primarily in orchard middles and not within the tree rows themselves, leading to a proportional implementation acreage. In other cases, GIS was used to model appropriate locations for practices like compost application that have specific slope, distance from water feature, and soil type requirements. With implementation acreages determined, the team then calculated expected carbon sequestration benefit for each practice through COMET-Planner, the CDFA Healthy Soils COMET-Planner, or other peer-reviewed method to arrive at an estimated total sequestration value.

This value represents the estimated annual total sequestration for each practice on Contra Costa County agriculture lands. Acreage of these practices, and by association sequestration cannot be summed to arrive at total acres engaged in carbon sequestration potential, as many of the practices could occur on the same land area. Management practices can, and should stack resulting in greater carbon sequestration, but that occurs on an individual farm level rather than in aggregate as this report calculates. While total carbon dioxide equivalents (CO_2e) sequestered can be summed, acres should not be.

Figure 2. An example of cover cropping, a climate smart management practice that is also fixing nitrogen for use by the next cash crop, providing other natural resource benefits beyond carbon sequestration. Photo taken by Ben Weise, December 2022.

Ultimately, this modeling exercise shows there is tremendous potential in Contra Costa County Agriculture to produce food, sequester carbon dioxide and other greenhouse gases (GHG), and address other natural resource concerns related to soil, water, air, and wildlife. Actual sequestration values will vary depending on individual grower adoption and education, as well as government and non-profit intervention and support to fund and implement these practices. A sensitivity analysis (Table 11) of these results found that the lowest dollar per metric tonne carbon dioxide sequestered as a result of a 1% change in implemented acreage was cover cropping and reduced/no-till tillage management practices followed by prescribed grazing, compost application, and native oak restoration/silvopasture. With additional support, financially through cost-share agreements and technically through technical assistance funding to RCDs, UC Cooperative Extension, and other farm and ranch support non-profits, we'd expect these practices to pay significant dividends and sequester carbon dioxide while also producing food and improving natural resource conditions relatively cheaply as compared to other natural carbon sequestering management practices.

Figure 3. Managed rangeland in the Shell Ridge Open Space in Walnut Creek, CA. Photo taken by Ben Weise, 2019.

Introduction

The purpose of this report is to document the methods, assumptions, and results of analysis to estimate the carbon sequestration potential on agricultural lands within Contra Costa county, including grazed rangelands, annual row crop vegetable systems, perennial orchards and vineyards, and urban farms and community gardens. This analysis was funded through a Sustainable Agricultural Lands Conservation (SALC) Grant Program through the California Department of Conservation and is part of a larger analysis being undertaken by the Contra Costa County Department of Conservation and Development that is assessing all Contra Costa lands, carbon stocks, and sequestration potential across land types and uses. The goal of this assessment is to support Contra Costa County in quantifying the potential contribution of working lands in meeting climate goals as identified in the County Climate Action Plan (CAP) and newly adopted General Plan through increased carbon sequestration and avoided future emissions.

Figure 4. Carbon farm planning at Urban Tilth's North Richmond Farm in April 2022. Photo taken by Ben Weise, 2022.

Enhancing photosynthetic carbon dioxide removal from the atmosphere through enhanced management of our natural and working lands offers the largest available pathway to draw down atmospheric carbon. Unlike engineering-based approaches, enhancing terrestrial carbon increases food security, enhances ecosystem resilience, and has myriad additional positive benefits for human, environmental, and economic health.

The analysis builds on the Carbon Cycle Institute's Carbon Farming framework to assess carbon sequestration potential at the landscape-scale using best available data, modeling tools, and expert opinion.

Setting

Contra Costa County is part of the San Francisco Bay Area and features a variety of land use types ranging from the highly urbanized western county (Hercules, Pinole, San Pablo, Richmond, El Sobrante, Rodeo, El Cerrito) the suburbanized central county (Martinez, Clayton, Concord, Walnut Creek, Pleasant Hill, San Ramon, Orinda, Lafayette, Moraga), and the suburban/rural eastern county (Pittsburg, Antioch, Oakley, Brentwood). Each of these "extents" is broken up by mountains and hills that form the Oakland/Berkeley Hills that join with other mountains to form the Diablo Range. Agriculture in Contra Costa County is diverse and consists of a variety of systems broadly including: grazed rangeland systems throughout the county in the upper hills and upper watersheds, annual row crop vegetable systems concentrated primarily in eastern Contra Costa on the edge of the Sacramento-San Joaquin Delta, perennial orchard and vineyard systems scattered throughout central and eastern Contra Costa, and urban farms and community gardens throughout the county.

Vegetable and seed row crop systems vary in acreage year to year depending on rotations and fallow periods, but typically account for 6500-7500 acres annually, mostly in sweet corn and tomatoes. In 2020, sweet corn and tomatoes accounted for ~5900 of the total 6,500 acres in vegetable and seed crop production. From there, the remaining 600 acres are split across a wide array of specialty crops, including asparagus, artichokes, beets, broccoli, cabbage, cardoon, carrots, cauliflower, cucumbers, eggplant, garlic, ginseng, green beans, greens, herbs, kohlrabi, lettuce, melons, mushrooms, okra, onions, peas, peppers, potatoes, pumpkins, radishes, squash, and wheatgrass (Contra Costa Department of Agriculture, Weights and Measures, 2020)

Figure 5. Rangelands in the Morgan Territory of Southern Contra Costa County, publicly owned land managed by the East Bay Regional Park District and actively grazed. Photo taken by Ben Weise, 2018.

Contra Costa rangelands are grazed almost entirely by cattle , including private ranches and public parks owned and managed by special districts or city governments. According to the 2020 Crop Report, approximately 148,000 acres of rangeland are grazed by livestock across Contra Costa County, mostly in the upper watersheds of the Oakland Hills, the Morgan Territory, and the Diablo Range (Contra Costa Department of Agriculture, Weights and Measures, 2020). An additional 5,450 acres of irrigated pasture land are also grazed, mostly along the periphery of the county on Sacramento-San Joaquin River Delta islands.

Perennial Orchard and Vineyard systems have increased in the recent past as growers have tended to favor higher cash, lower input perennial systems that don't require annual planting and maintenance. In 2020, there were 4,400 acres of fruit and nut crops, 1,940 of which were in grape systems followed by 824 acres of cherries. The remaining 1,500 acres are scattered across apricots, nectarines, olives, peaches, plums & pluots, walnuts, and other miscellaneous fruits and nuts (Contra Costa Department of Agriculture, Weights and Measures, 2020)

Figure 6. Compost piles and row crops at Family Harvest Farm, an urban farm on PG&E owned power line easements in Pittsburg. Photo taken by Ben Weise, 2022.

Urban Farm and community gardens systems are on the rise in Contra Costa county in response to local food needs in areas of low food access. These farms and gardens provide local food to their immediate neighborhood and community. These farms are located in highly urbanized and suburbanized areas, typically on the edges of urban land, in vacant lots and in-fill opportunities, schools, community centers, hospitals, and all manner of other locations. The true acreage of urban farms, school gardens, community gardens, and other similar spaces is currently unknown, but efforts are underway to aggregate a census of Urban Agriculture (UCCE Link). A cursory estimate of known urban farms by CCRCD Staff, UCCE Staff, and UCCE Master Gardeners accounted for ~72 total acres across Contra Costa county (personal communication between Ben Weise and Rob Bennaton, UC Cooperative Extension, Contra Costa, October 2022). This is likely an underestimate of the true acreage, as more urban farms and gardens are being developed, but within the right scale as urban agriculture is likely some time from exceeding 100 acres.

Methods

This analysis ultimately required two inputs; the agricultural acreage of Contra Costa County urban farms, ranches, and row-crop systems, and the estimated potential implementation acreage of the various management practices. With those data points, planners used the COMET-Planner GHG quantification tool developed for the California Department of Food and Agriculture Healthy Soils Incentives Program (http://comet-planner-cdfahsp.com/). COMET-Planner was developed by a research team out of Colorado State University in partnership with the USDA NRCS and the Marin Carbon Project, and is a model that quantifies carbon dioxide equivalent (CO_2e) sequestration values for a variety of farm and ranch management practices, given an implementation acreage. More information on COMET-Planner is available online (http://comet-planner.com/). The CDFA Healthy Soils Comet Planner was developed specifically for use in California to support producer applications to the Healthy Soils Program.

Determining Agricultural Acreage

The spatial extent of the study included all agricultural lands in Contra Costa County as mapped through the California Department of Conservation Farmland Mapping and Monitoring Program (FMMP) (California Department of Conservation, 2023), cross-referenced with available Contra Costa County Agricultural Reports (Contra Costa Department of Agriculture, Weights and Measures, 2020) and LANDFIRE Data (US Dept. of Agriculture and US Dept. of Interior, 2022). The goal of the FMMP is to provide consistent data to decision makers for use in assessing the status of and trends in California's agricultural land resources. FMMP county-level map data is updated every two years, utilizing aerial imagery, public review, and field reconnaissance. The FMMP agricultural land resources data is divided into five farmland mapping categories (see table below). In Contra Costa County, 254,499 acres of agricultural land was mapped in 2018. Important farmland mapping categories and soil taxonomy terms can be found on the DOC Website (https://www.conservation.ca.gov/dlrp/fmmp). While a good resource to start with, this data set includes all suitable lands that could be grazed, including acreage not currently grazed, like Mt. Diablo State Park. Ultimately, FMMP data and maps allowed the project team to compare data sets to ensure that we were working with consistent data.

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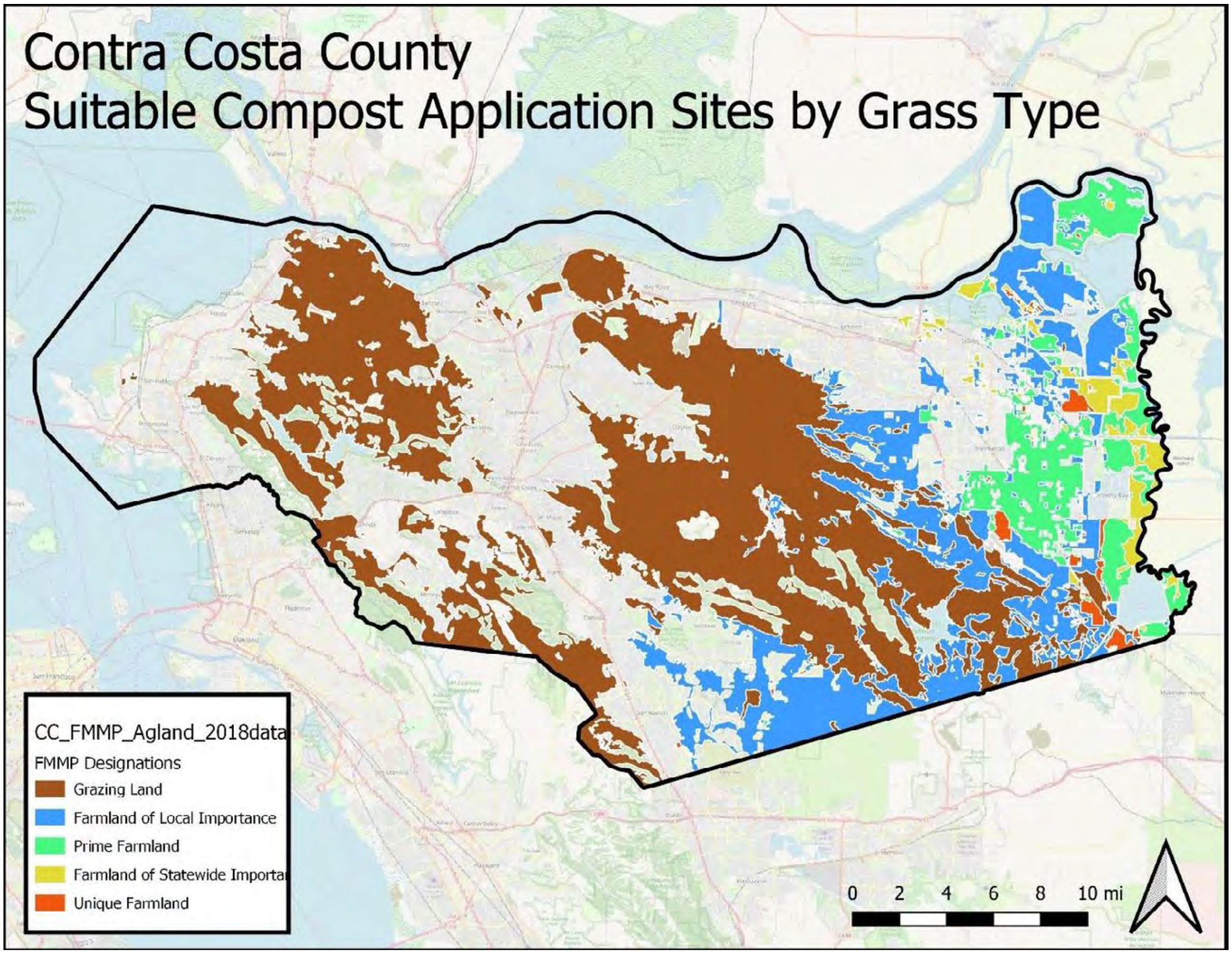
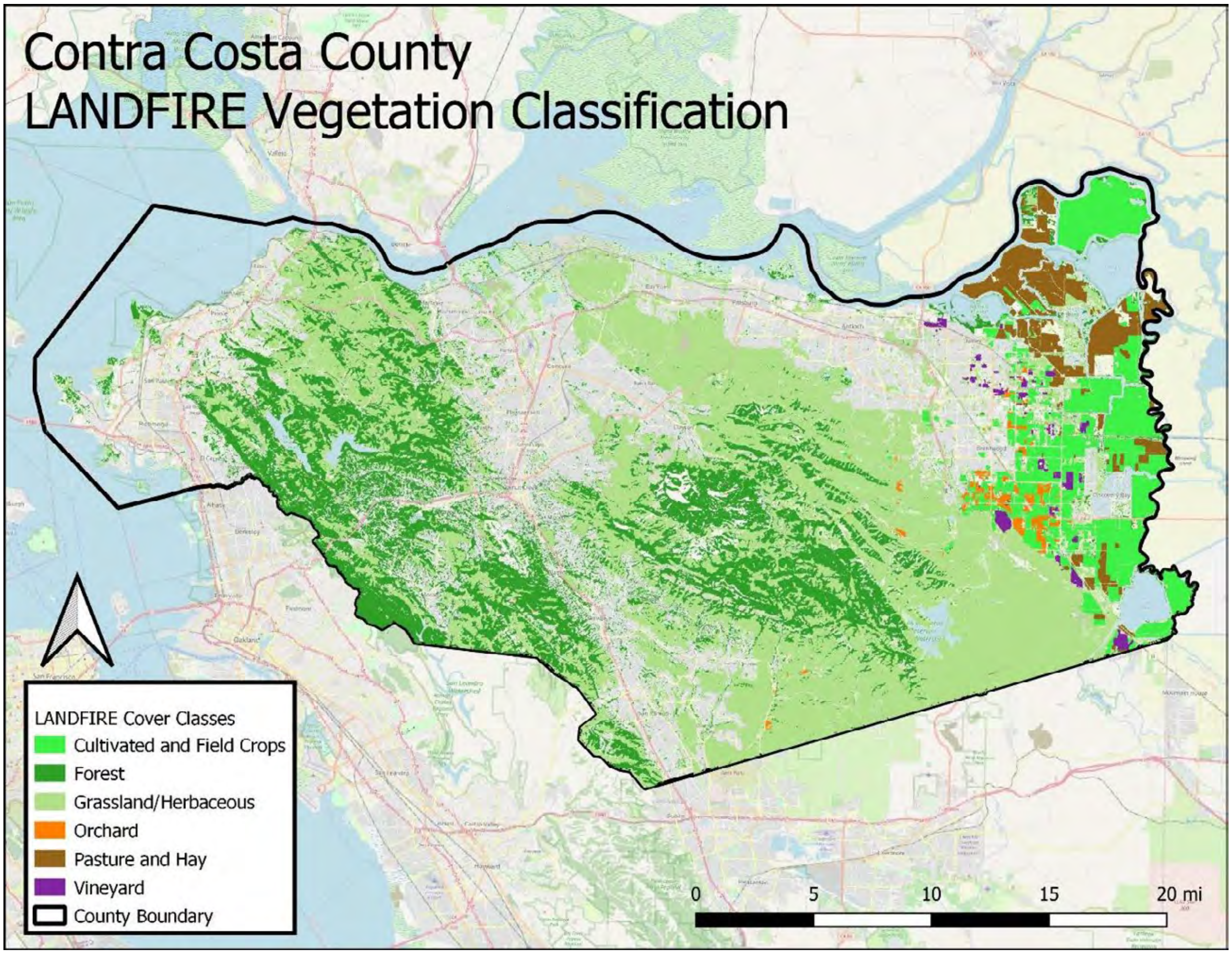
Table 1. Farmland Mapping and Monitoring Program Land Classifications, Definitions, and Acreages within Contra Costa county in 2020

FMMP Land Type	Definition	Acres
P (Prime Farmland)	Prime Farmland has the best combination of physical and chemical features able to sustain long-term agricultural production. This land has the soil quality, growing season, and moisture supply needed to produce sustained high yields. Land must have been used for irrigated agricultural production at some time during the four years prior to the mapping date.	25,173.8
S (Farmland of Statewide Importance)	Farmland of Statewide Importance is similar to Prime Farmland but with minor shortcomings, such as greater slopes or less ability to store soil moisture. Land must have been used for irrigated agricultural production at some time during the four years prior to the mapping date.	7,592.4
U (Unique Farmland)	Unique Farmland consists of lesser quality soils used for the production of the state's leading agricultural crops. This land is usually irrigated, but may include non-irrigated orchards or vineyards as found in some climatic zones in California. Land must have been cropped at some time during the four years prior to the mapping date.	3,291.1
L (Farmland of Local Importance)	The lands within the Tassajara area, extending eastward to the county boundary and bordered on the north by the Black Hills, the Deer, Lone Tree and Briones Valleys, the Antioch area, and the Delta. These lands are typically used for livestock grazing. They are capable of producing dryland grain on a two year summer fallow or longer rotation with volunteer hay and pasture. The farmlands in this category are included in the U.S. Natural Resources Conservation Service's Land Capability Classes I, II, III, and IV, and lack some irrigation water.	6,1017.2
G (Grazing Land)	Grazing Land is land on which the existing vegetation is suited to the grazing of livestock.	157,424.5



Map 1. California Department of Conservation Farmland Mapping and Monitoring Program Land within Contra Costa County. Map created by Ben Weise and Johnathan Wachter.

As another part of the "Healthy Lands, Healthy People" grant, Rincon Consultants, Inc. used LANDFIRE data to derive approximate acreage of various cropping systems (see "Contra Costa County Data Evaluation, Land Cover Classification, and Land-based Carbon Inventories and Baseline Projection Methodology Memorandum by Rincon Consultants, Inc.). The 2021 LANDFIRE data was compared to the Contra Costa County 2020 Crop Report data and was found to be similar enough to warrant its use. For consistency across the "Healthy Lands, Healthy People" project, we used LANDFIRE data to inform agricultural acreage as LANDFIRE classifies agricultural land by type (field crops, tree crops, vineyards, etc.). Table 2 below compares LANDFIRE reported data with Contra Costa County 2020 Crop Report data.



Map 2. LANDFIRE Vegetation Classifications within Contra Costa County. Map created by Ben Weise and Johnathan Wachter.

Urban Farm data is an estimate of currently known urban farms, community gardens, and school gardens in Contra Costa County by UCCE Staff, UCCE Master Gardeners, and CCRCD Staff (R. Bennaton, personal communication, Fall 2022). This is likely an underestimate, as many groups probably haven't connected with UCCE Staff or CCRCD Staff, but within the correct scale. The project team believes that there is likely an upper limit on existing urban agriculture close to ~150 acres at this time. UCCE Staff are currently conducting an urban farm/community garden census for the wider San Francisco Bay Area, but the results of this effort were not completed in time for use in this project. Future updates should use this UCCE data source as it will represent the best available data and knowledge for urban farm, community, and school garden spaces in Contra Costa County.

Table 2. LANDFIRE Land Use Acreages compared against 2020 Contra Costa County Agricultural Commissioner's Report: Reported Crop Acreages

Data Source	Land Use	Acreage
LANDFIRE	Cultivate Land and Field Crops*	27,342
2020 Crop Report	Field Crops, Vegetable and Seed Crops	25,360
LANDFIRE	Orchards and Vineyards*	4,222
2020 Crop Report	Fruit and Nut Crops	4,465
2020 Crop Report	Rangeland*	148,000
2020 Crop Report	Irrigated Pasture*	5,450
UCCE/CCRCD Estimate	Urban Agriculture*	72

*Selected data set for analysis

This spatial and acreage data was then used to model climate mitigation benefits from the adoption of specific agricultural land management practices. The study relied primarily on the CDFA Healthy Soils Program version of the NRCS and Colorado State University COMET-Planner tool (http://comet-planner-cdfahsp.com/) for quantification of carbon sequestration and greenhouse gas emission reduction benefits associated with changes in agricultural land management practices, by crop type, on an annual per acre basis. Estimates were also derived using relevant literature from Ryals et al. 2015 for Rangeland Compost Estimate and Matzek et al. 2020 for Rangeland Riparian Restoration (see Citations in Appendix).

Table 3 below details each of the management practices included in this study, the related CO_2 Sequestration and Emissions Reduction Coefficient used the source of that number, and the expected lifespan of the management practice according to USDA NRCS EQIP Standards and Specifications. Additional information about each management practice along with definitions and descriptions can be found in Appendix III.

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Table 3. NRCS EQIP/CDFA HSP Management Practices, Sequestration and Emissions Reduction Coefficients, and Expected Practice Lifespan

	Management Practice	Sequestration and Emissions Reduction Coefficient*	Expected Practice Lifespan (Years)**	Source
Row Crops	Cover Cropping	0.400	1	CDFA COMET-Planner
	Mulching	0.210	5	CDFA COMET-Planner
	Compost Application & Nutrient Management	4.450	6	CDFA COMET-Planner
	Hedgerow Planting	8.410	34	CDFA COMET-Planner
	Windbreak/Shelterbelt Establishment	8.410	80	CDFA COMET-Planner
	Riparian Forest Buffer	1.980	20	CDFA COMET-Planner
	Riparian Herbaceous Cover	0.630	10	CDFA COMET-Planner
	Field Border	1.230	20	CDFA COMET-Planner
	Alley Cropping	0.810	15	CDFA COMET-Planner
	Conservation Crop Rotation	0.260	1	CDFA COMET-Planner
	Residue and Tillage Management - Reduced Till	0.120	1	CDFA COMET-Planner
	Residue and Tillage Management - No Till	0.220	1	CDFA COMET-Planner
Urban Farms	Cover Cropping	0.400	1	CDFA COMET-Planner
	Mulching	0.210	5	CDFA COMET-Planner
	Compost Application & Nutrient Management	4.450	6	CDFA COMET-Planner
	Hedgerow Planting	8.410	34	CDFA COMET-Planner
	Windbreak/Shelterbelt Establishment	8.410	80	CDFA COMET-Planner
	Field Border	1.230	20	CDFA COMET-Planner
	Alley Cropping	0.810	15	CDFA COMET-Planner
	Conservation Crop Rotation	0.260	1	CDFA COMET-Planner
	Residue and Tillage Management - Reduced Till	0.120	1	CDFA COMET-Planner
	Residue and Tillage Management - No Till	0.220	1	CDFA COMET-Planner
Grazi	Compost Application to Rangelands	4.540	20	CDFA COMET-Planner
	Prescribed Grazing (Rangelands)	0.008	10	CDFA COMET-Planner
	Prescribed Grazing (Irrigated Pasture)	0.105	10	CDFA COMET-Planner

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	Management Practice	Sequestration and Emissions Reduction Coefficient*	Expected Practice Lifespan (Years)**	Source
	Native Oak Restoration/Silvopasture	0.660	80	CDFA COMET-Planner
	Riparian Restoration	9.160	20	Matzek et al. 2020
	Range Planting	0.340	10	CDFA COMET-Planner
Orchards and Vineyards	Cover Cropping	1.640	1	CDFA COMET-Planner
	Mulching	0.340	6	CDFA COMET-Planner
	Compost Application & Nutrient Management	4.540	1	CDFA COMET-Planner
	Hedgerow Planting	8.200	34	CDFA COMET-Planner
	Windbreak/Shelterbelt Establishment	8.200	80	CDFA COMET-Planner
	Residue and Tillage Management - Reduced Till (Vineyard)	0.120	1	CDFA COMET-Planner
	Residue and Tillage Management - No Till (Vineyard)	0.350	1	CDFA COMET-Planner
	Residue and Tillage Management - Reduced Till (Orchard)	0.120	1	CDFA COMET-Planner
	Residue and Tillage Management - No Till (Orchard)	0.350	1	CDFA COMET-Planner
	Whole Orchard Recycling (Orchard)	0.040	20	CDFA COMET-Planner

*Units are tonnes CO_2e per acre per year

**This is the expected lifespan of the practice per NRCS Standard and Specifications

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Carbon Sequestration Measures

Determining Applicable Climate Smart Management Practices

COMET-Planner, our primary greenhouse gas sequestration quantification tool, ultimately relies on USDA NRCS EQIP Management Practice Standards and Specifications for ease of replicability across the country. Ultimately, management practices deployed need to closely resemble the NRCS Practice Standard for an accurate accounting of sequestration benefits. CDFA Healthy Soils Incentives Program practices are nearly identical to NRCS EQIP Practices and use NRCS Standards and Specifications for verification. To determine climate beneficial agricultural land management practices for inclusion in this report then, the project team use three different methods.

Figure 7. Mulch waiting to be placed in orchard rows as part of a suite of climate-smart agriculture practices at Frog Hollow Farm in Brentwood. Photo taken by Ben Weise, 2018.

First, management practices were selected based on current grower adoption as measured through US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) contract enrollment data (C. Hernandez, personal communication, July 2022.) This information was aggregated based purely on the number of EQIP applications since 2017 and does not include any grower personal identification information.

Second, the project team used historic CDFA Healthy Soils Program Application Data (B. Weise, personal communication, July 2022). CCRCD has served as a Technical Assistance Provider under the CDFA Healthy Soils Program since 2017 and has helped numerous individuals apply to the program in that time. CCRCD Staff referenced historical applications and pulled relevant data (implementation acreage of a practice, total acreage of operation, farm type) while protecting personal identification information. Combined with NRCS EQIP Data, these selected practices represent current knowledge of climate-smart management practices that producers are familiar with and/or currently being paid to implement within Contra Costa County.

Third, as part of the larger “Healthy Lands, Healthy People” project, the University of California Cooperative Extension, Concord office, conducted a series of focus groups and a survey to further glean agricultural producer/landowner awareness and opinion on additional management practices. Based on the results of those focus groups and surveys, further management practices were determined in conversations with University of California Cooperative Extension staff and the Contra Costa Resource Conservation District that could feasibly be implemented in various Contra Costa agricultural systems (K. Aram, R. Bennaton, personal communication, 2022). These practices were often performed by the land manager or farmer, without funding assistance, but sometimes not fully to NRCS Standard and Specification. Despite this, the practices are still being adopted and utilized in Contra Costa county, and could be further adopted with better support.

Determining Implementation Acreage on Row Crop/Orchard/Vineyard/Urban Farm/Grazing Systems

With management practices determined and farm/crop acreages known, the project team needed to determine implementation acreages of each practice in order to model potential sequestration values. Normally during the carbon farm planning process, planners would visit, ask questions, determine implementation needs, look at resource concerns on the property, etc. and develop an implementation acreage in conversation with the landowner on a per farm basis. This is traditionally a time-intensive effort conducted over many meetings, phone calls, emails, and site visits. Given the scale of Contra Costa Agriculture, the project team utilized two different methods to determine implementation acreage.

For clarification of terms used within this report, we’ve described below the differences between “total farm acreage”, “total cultivated acreage”, and “total implementation acreage. Ultimately, “total farm acreage” and “total cultivated acreage” are data points needed to determine “total implementation acreage”.

<u>Total Farm Acreage</u>

Total Farm Acreage refers to the total acreage of a farming operation, inclusive of everything including barns, buildings, ditches, roads, property lines, etc. Total farm acreage and can reasonably be taken to mean total farm parcel size. It's important to note that total farm acreage does not equal total cultivated acreage.

Total Cultivated Acreage

Total cultivated acreage encompasses the total cultivated acreage within the total farm acreage. Total cultivated acreage will always be less than total farm acreage, as total cultivated acreage does not include things like barns, farm roads, irrigation ditches, etc. While imperfect, LANDFIRE provides a rough analysis of total cultivated acreage. As a reminder, LANDFIRE classifies land cover as vegetated or not, and then further classifies vegetation as cultivated or not. LANDFIRE does have a known resolution constraint, however, because it categorizes vegetation on a resolution of 30 meters (30 meter resolution means that two objects, thirty meters long or wide, sitting side by side can be distinguished from each other). Ultimately, this may effect some of the acreage totals due to misclassified vegetation type, and/or cultivated versus uncultivated acreage. However, LANDFIRE is still the best available data for this analysis, and comparisons with the 2020 Contra Costa Department of Agriculture's showed that the two data sets are largely in agreement.

Total Implementation Acreage

Implementation acreage is the area on which a management practice could reasonably be implemented. Implementation acreage coefficients were developed for some selected management practices based on real world planning done by CCRCD and NRCS Staff (See Appendix I). In other instances, implementation acreage was developed in conversation with experts.

To best illustrate these different acreage types, consider a hypothetical farm. This farm, according to county level parcel data, has a total farm area of 10 acres. Within that parcel is non-cultivated acreage totaling one acre that includes a house, barn, and lawn, roads, an irrigation ditch, etc., while the rest of the parcel is a cultivated orchard, meaning the total cultivated acreage is 9 acres. The farm is interested in implementing cover crops between the rows of the trees, leading to a cover crop implementation acreage of 6.3 acres (CDFA through the Healthy Soils Program has defined implementation acreage for cover crops in an orchard system to be 70% of total cultivated area). In this example cover crops are grown in the alleys between trees, but not within the tree rows, hence the decreased implementation acreage.

Planners used total implementation acreage by practice to estimate total sequestration potential as a result of implementing that individual practice. In some cases, implementation of one practice means that another practice cannot be implemented. For example, a farmer cannot choose to implement the "Tillage Management – Reduced Till" and "Tillage Management – No Till" on the same area. Implementation acreage, and by association, sequestration potential cannot be summed for this reason. See Appendix I for a description of how these implementation acreages were determined.

Figure 8. An example drawing where the blue square represents Total Farm Acreage, the red polygon represents Total Cultivated Acreage. Implementation acreage can vary but could be the whole cultivated acreage, the rows between trees, etc.

For grazing lands and irrigated pasture, most of the implement acreages for management practices were calculated using geographic information system analysis (see next section) where appropriate. For Prescribed Grazing however, the project team assumed total implementation acreage was equal to total farm acreage. In a prescribed grazing plans, all lands, roads, buildings, etc. are included to develop a grazing plan that achieves farmer and conservation objectives, so the project team used total farm acreage as total implementation acreage.

Determining Implementation Acreage with GIS

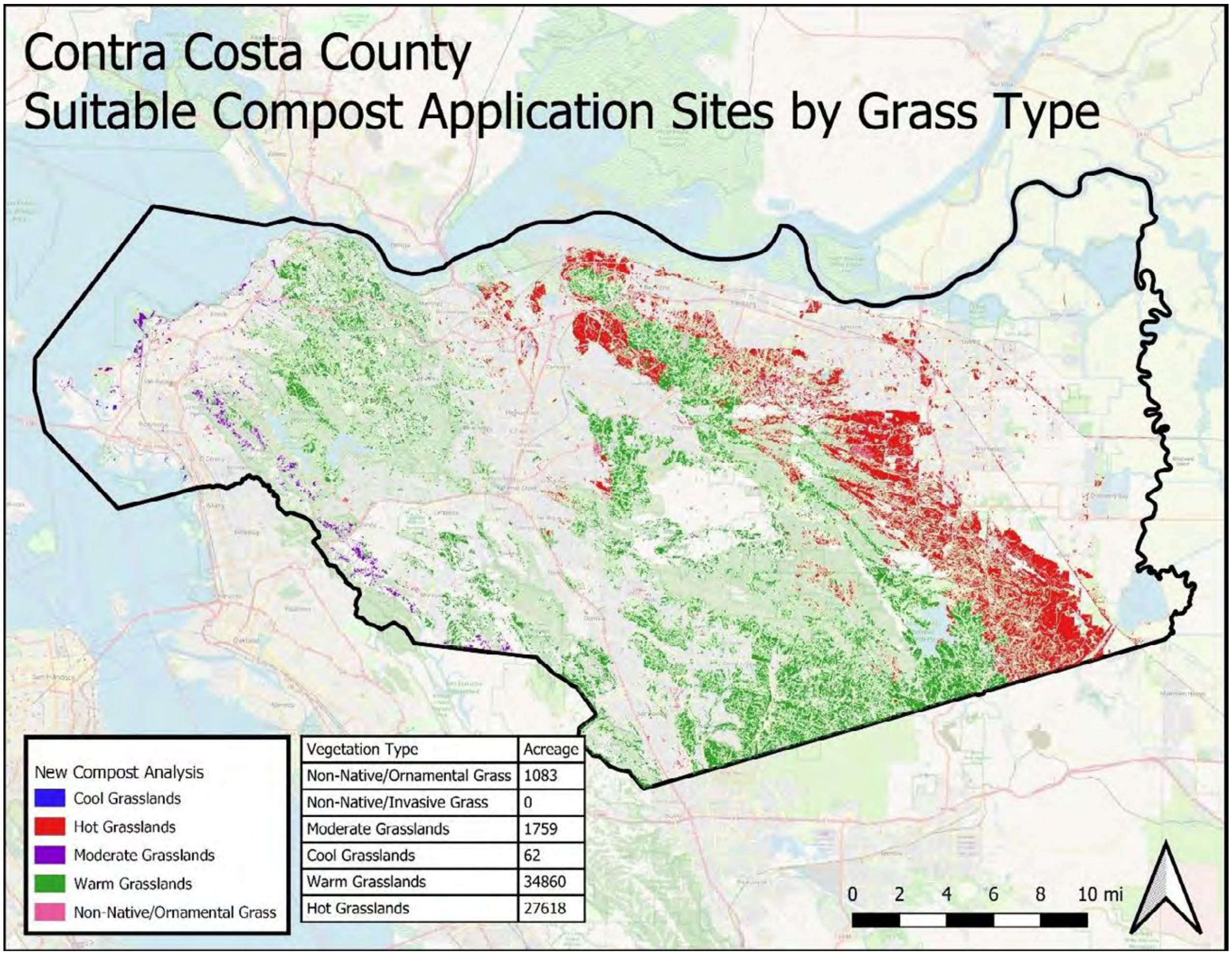
The project team determined additional implementation acreage for some management practices with the use of geographic information system (GIS) analysis and available raster and vector data. GIS was used to determine implementation acreage for these practices because they have specific constraints that could be modeled geospatially. As an example, compost application to rangelands has slope constraints, vehicle access constraints, and water-proximity constraints, to name a few. Through GIS, we identified suitable grassland areas on slopes less than 15% that also had vehicular access and were sufficiently far from water features to buffer potential runoff into creeks, ponds, or other water bodies. Each section below details the GIS analysis methodology used to derive implementation acreage for specific management practices.

Note that while a reasonably good estimate, the following implementation acreages are built on the LANDFIRE data set with a current resolution of 30-meters. This resolution, while the best available, does have the potential to include acreages that aren't actually agricultural, and miss acres that are agricultural, True implementation acreage, and by extension, sequestration potential, can be expected vary somewhat from what is estimated here,

Compost Application on Rangelands

To determine preliminary potential implementation acreage for compost application to rangeland systems, the project team started by working within the "Grassland/Herbaceous Cover" feature from the 2021 LANDFIRE data layer. County slope data (Contra Costa County Government, 2014) was used to eliminate all areas within these feature classes that exceeded 15% slope (CDFA Healthy Soils Program currently will not fund compost application to slopes greater than 15%). Next, all areas within 30 meter of water features were removed (as identified by the National Wetlands Inventory database (US Fish and Wildlife Service, 2022) and identified as Open Water by LANDFIRE). Next, all areas with hydric (wetland) soils were removed (as identified by SSURGO's Hydric Rating field (USDA Natural Resources Conservation Service, 2022)). From there, the remaining acreage was intersected with the Conservation Lands Network 2.0 Vegetation layer (Conservation Lands Network, 2022) and removed all vegetation identified as perennial grasses and forbs, serpentine vegetation, and non-grassland vegetation types. The remaining area has vegetation classified by the Conservation Lands Network 2.0 Vegetation layer as Non-Native/Ornamental Grass, Cool Grasslands, Hot Grasslands, Moderate Grasslands, and Warm Grasslands.

The resulting area can be thought of as a first biophysical mapping filter, pending further input from County experts and practitioners. This is not a prescriptive map, nor is it a final map of recommended areas to receive compost. Rather, this map simply shows the result of the overlaying of variables described above and identifies those areas theoretically eligible for compost application under the CDFA Healthy Soils Program. This map does not constitute a recommendation, as there are a number of other variables involved, like equipment access, soil health, rangeland health, wildlife presence, etc. that impact the acreage estimate. Site assessment would be required before any compost is applied to these identified landscapes.



Map 3. Suitable Compost Application Areas in Contra Costa County by Grass Type (Cool, Moderate, Warm, Hot) Data Sources: LANDFIRE, National Wetlands Inventory Database, Soil Survey Geographic Database, Conservation Lands Network 2.0 Dataset. Map created by Ben Weise and Johnathan Wachter.

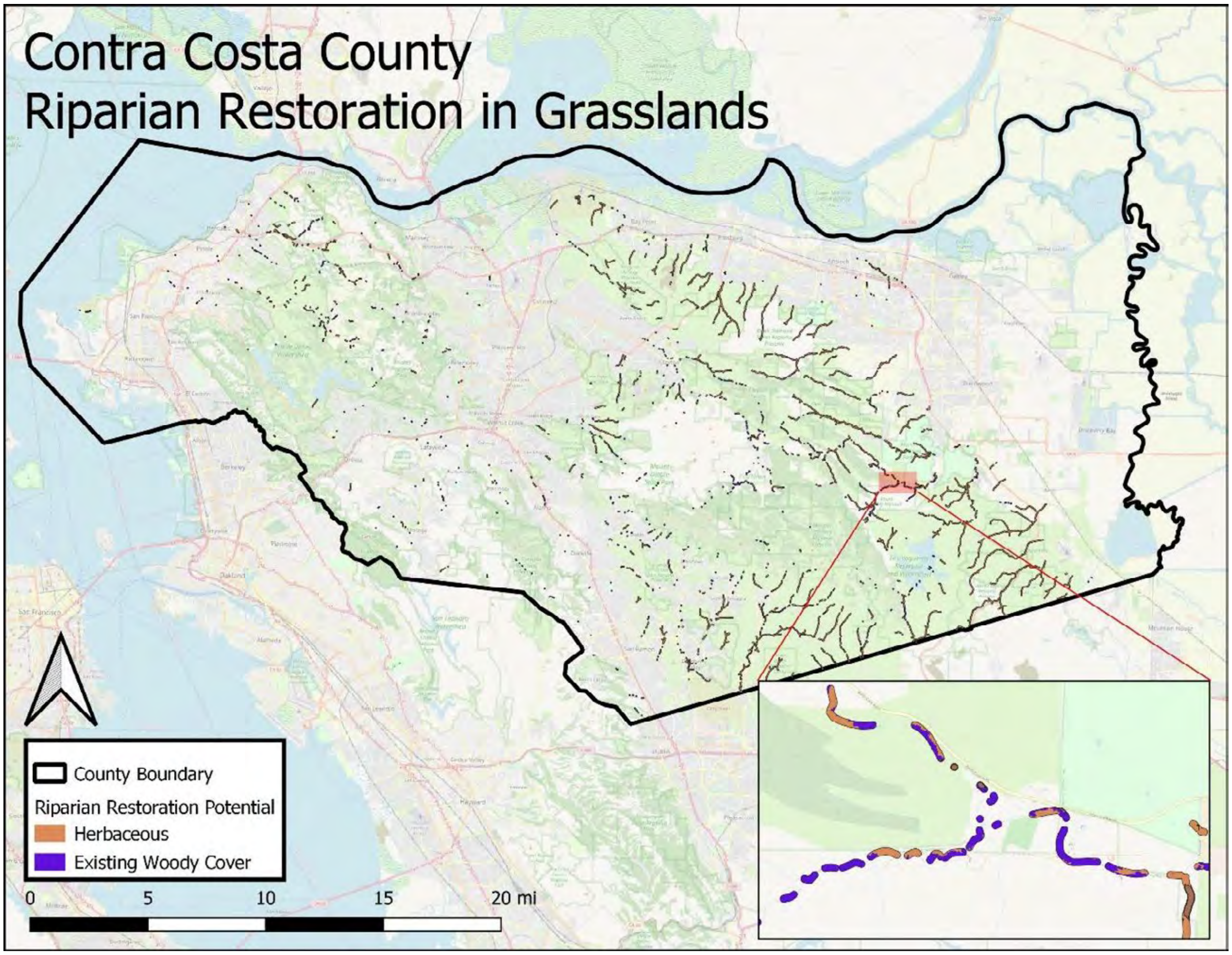
Table 4. Suitable Compost Application Acreages by Grass Type

Vegetation Type	Acreage
Cool Grasslands	62
Moderate Grasslands	1,759
Hot Grasslands	27,618
Warm Grasslands	34,860
Total*	64,299

*The analysis excluded Non-Native/Ornamental Grass despite significant acreage (1,083 acres) as closer investigation found these areas were predominantly golf courses, cemeteries, sports fields, or other non-agricultural uses. Likewise, non-native/invasive grass, while a vegetation type present in the county, has no acreage having been removed by one of the many restricting factors (slope, proximity to water features, etc.)

Riparian Forest Buffer and Riparian Herbaceous Cover

To determine implementation acreage for riparian restoration practices, we used the California Fish and Wildlife California Streams layer (California Department of Fish and Wildlife, 2020) and clipped to streams found on grasslands using the LANDFIRE 2021 Grasslands layer. The layer was further clipped to include only streams found in stream valleys, identified by the Conservation Lands Network 2.0 Stream Valley data layer (Conservation Lands Network, 2022). This allows us to focus only on streams of a high enough order and persistent enough moisture to facilitate riparian restoration. Next, we added a 24-meter buffer to these streamlines to delineate the riparian corridor area, consistent with the methodology developed by Matzek et. al (2020) The resulting riparian area was then overlaid with the Conservation Lands Network 2.0 vegetation layer to determine how much of this riparian area is currently covered in woody vegetation versus herbaceous vegetation. Riparian area under herbaceous vegetative is considered to be a prospective opportunity for establishing woody riparian vegetation. Estimated acres are expected to include significant sources of error due to differences in data layer resolution and the potential for some stream lines to be misaligned with mapped vegetation. The resulting area can be thought of as a first biophysical mapping filter, pending further input from County experts and practitioners. This is not a prescriptive map, In Map 4 below, the inset illustrates a section of creek covered by both woody and herbaceous plant cover. The analysis is performed on areas with only herbaceous plant cover, as woody planted areas are assumed not to need additional woody plantings.



Map 4. Potential riparian restoration areas within Contra Costa County rangelands. Data Source: California Fish and Wildlife Streams Layer, LANDFIRE Vegetation Data, Conservation Lands Network 2.0 Map created by Ben Weise and Johnathan Wachter.

Table 5. Vegetation Types along Riparian corridors in rangeland settings

Vegetation Type (Conservation Lands Network 2.0)	Acreage
Herbaceous (various grasslands)	2,690
Woody Vegetation (various)	512
Implementation Acreage	2,178

Oak Restoration/Silvopasture

Two different approaches were used to estimate grassland areas with potential for oak establishment, a native silvopastoral practice on rangelands.

The first approach used LANDFIRE's Biophysical Setting database (BPS) to estimate potential areas for oak woodland re-establishment. The BPS represents the vegetation system that may have been dominant on the landscape prior to Euro-American settlement and is based on

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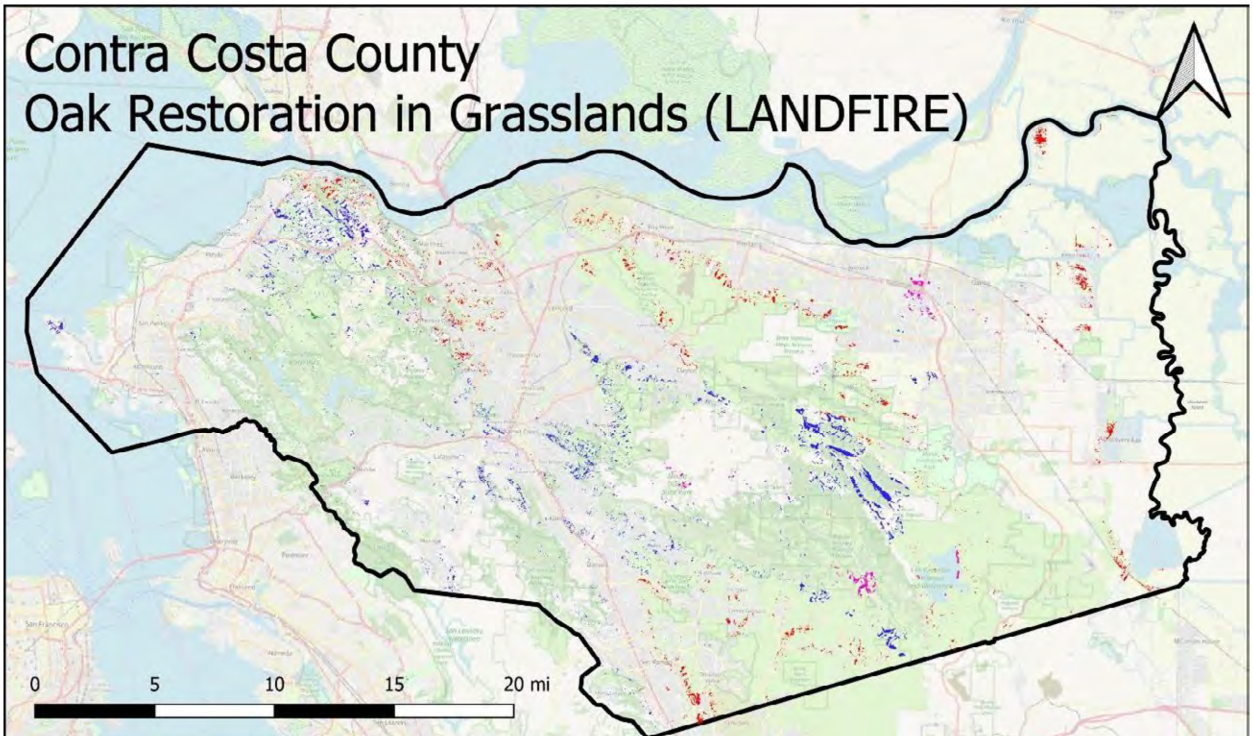
current environment and approximate historical disturbance regimen (reference). The project team started from this database and focused on the six oak woodland and savannah categories it contains. This layer was clipped to the Rincon 2021 LANDFIRE Grassland Layer. The new layer was then clipped to areas covered in grass vegetation according to the Conservation Land Network 2.0's vegetation layer.

This results in a layer of grassland areas in Contra Costa County that possess the biophysical characteristics necessary to support oak woodlands and savannas, an approximate implementation acreage for Oak Restoration and Silvopasture. Map 5 (below) is not a prescriptive map, nor is it a final map of recommended areas in which to plant oaks. Further input from County experts and practitioners should be used to refine these recommendations.



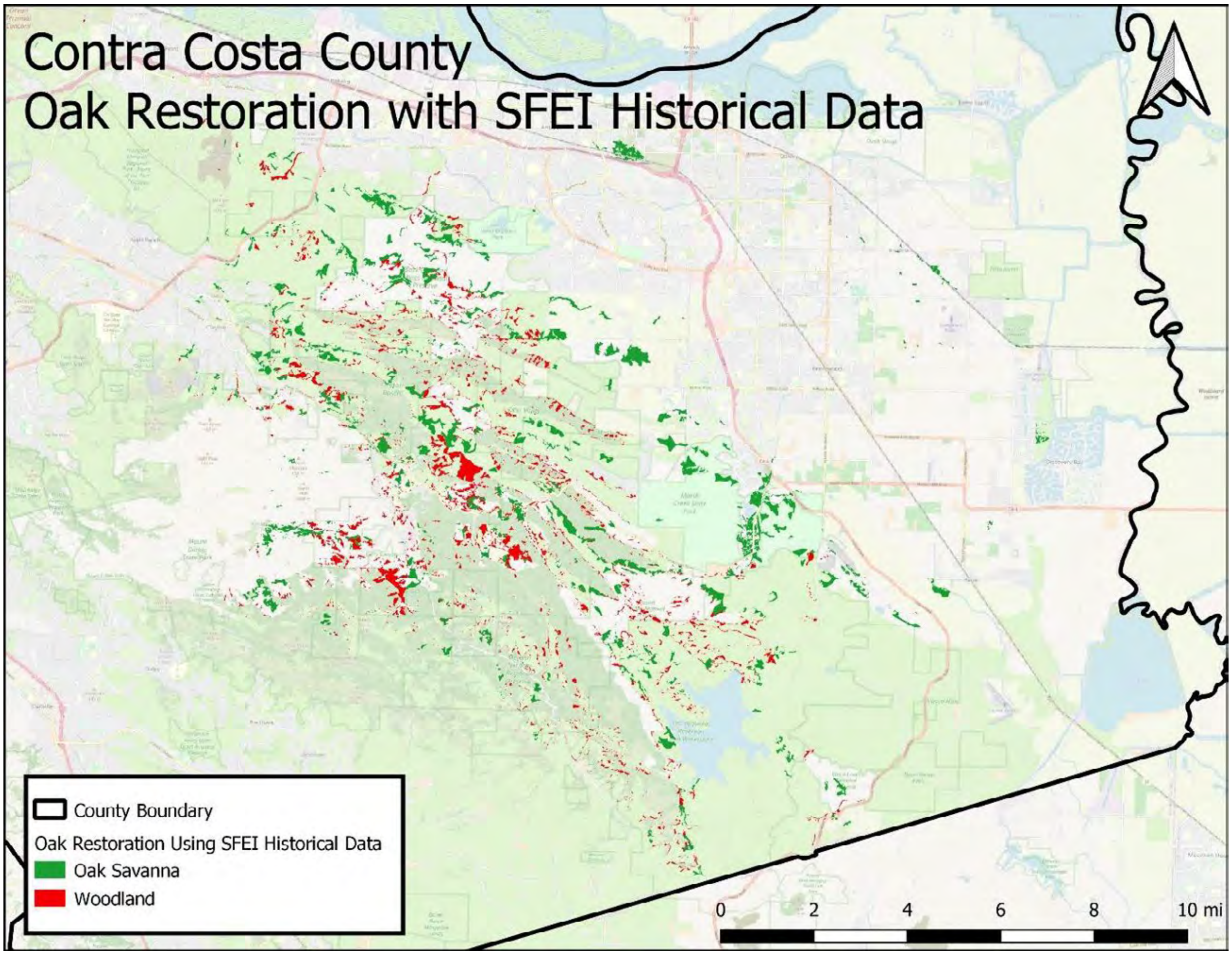
Biophysical Setting Name	Acres
Mediterranean California Mixed Oak Woodland	0
California Central Valley Mixed Oak Savanna	3006
California Coastal Live Oak Woodland and Savanna	4987
California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna	486
California Montane Woodland and Chaparral	143
Southern California Oak Woodland and Savanna	0

Map 5. Potential Oak Restoration (Silvopasture) Areas within Contra Costa County using LANDFIRE Data Data Source: LANDFIRE Data, Conservation Land Networks 2.0 Data. Map created by Ben Weise and Johnathan Wachter.

Table 6. Acreage of biophysical settings suitable for oak establishment and restoration in Contra Costa County

Biophysical Setting (LANDFIRE 2020)	Acres
California Central Valley Mixed Oak Savanna	3,006
California Coastal Live Oak Woodland and Savanna	4,987
California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna	486
California Montane Woodland and Chaparral	143
Total	8,622

The second approach used a 2011 Historical Ecology study conducted by the San Francisco Estuary Institute for east Contra Costa County (San Francisco Estuary Institute, 2011). The study mapped estimated historical habitat types covering East Contra County. This layer was clipped to the Rincon 2021 LANDFIRE Grassland Layer. The new layer was then clipped to areas covered in grass vegetation according to the Conservation Land Network 2.0's vegetation layer. This results in a layer of grassland areas in east Contra Costa County that were determined to have historically supported oak woodlands and savannas, used to approximate implementation acreage for Oak Restoration and Silvopasture. This is not a prescriptive map, nor is it a finalized map of recommended areas to plant oaks. Further input from County experts and practitioners should be used to refine these recommendations.



Map 6. Potential Oak Restoration (Silvopasture) Areas within Contra Costa County using SFEI Historical Data
Data Source: LANDFIRE Data, Conservation Lands Network 2.0 Data, San Francisco Estuary Institute 2011 Historical Ecology Study. Map created by Ben Weise and Johnathan Wachter.

Table 7. Estimated historical Oak Savannah and Woodland habitat in Contra Costa County that could be restored

Estimated Historical Habitat (SFEI 2011)	Acres
Oak Savannah	3,879
Woodland	2,649
Total	6,528

While there is some overlap between the two methods, this analysis uses the LANDFIRE-derived estimate both for consistency with other data, and because it represents current biophysical settings that could reasonably be expected to support oak establishment. The SFEI Historical method is included here to add additional context, and could further inform additional oak restoration opportunities, but would need to be more closely vetted to determine actual feasibility of oak establishment on those sites.

Range Planting

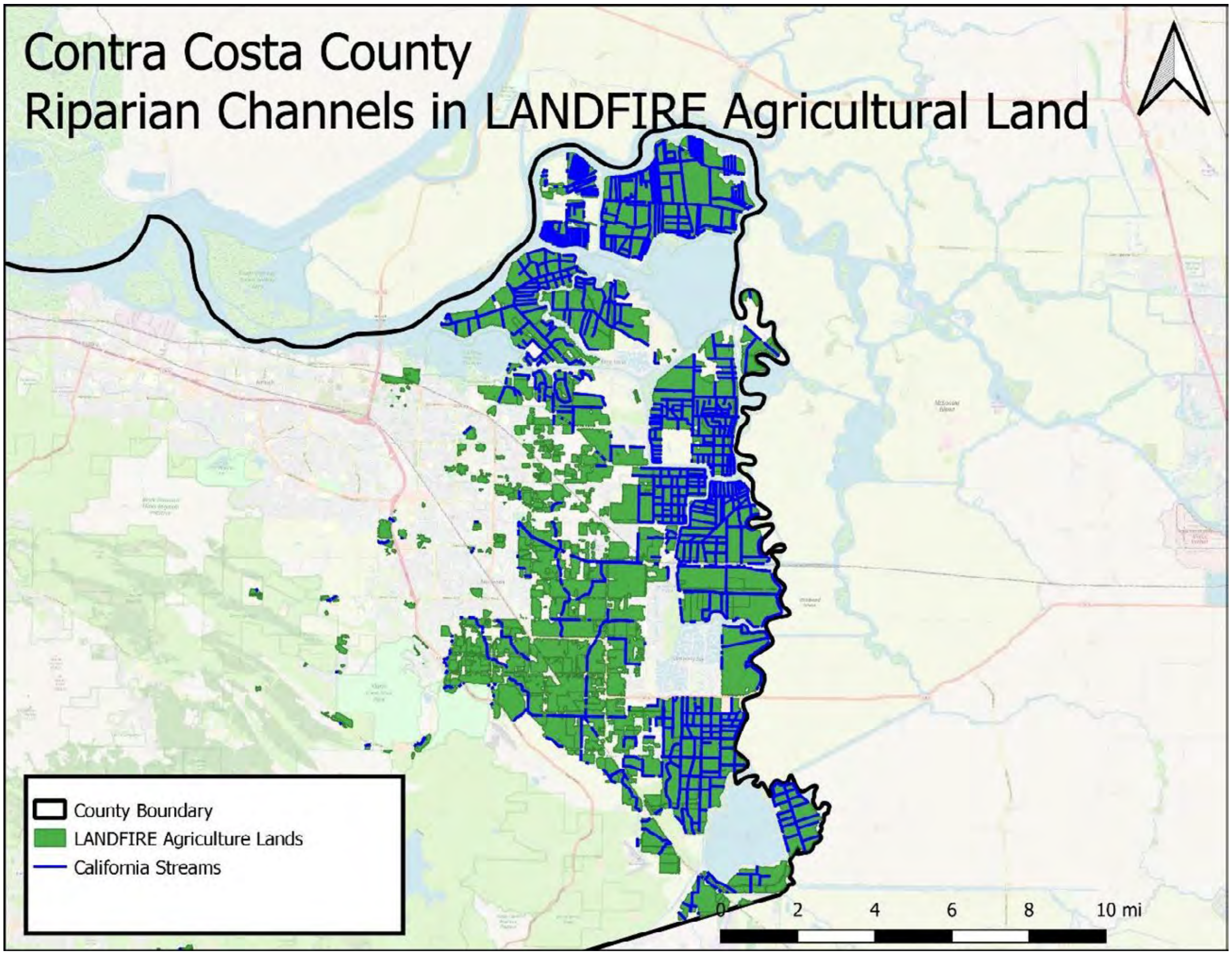
Acreage suitable for Range Planting was calculated using the Range Drill Suitability Report available via the NRCS SSURGO Database (USDA Natural Resources Conservation Service, 2022). The tool includes factors like soil type, slope, and safe vehicular/equipment operation to classify rangelands into 4 categories: not rated, poorly suited, moderately suited, and well suited. This tool does not take into account whether a given rangeland is actively grazed or even in need of planting. Rather it identifies local conditions suitable to facilitate a successful range planting. The results of this analysis are shown in table 7 below. Based on the analysis 25,853 acres, were identified as “Moderately suited” or “Well suited’ for Range Planting.

Table 8. Acreage of range drill suitability for range planting in Contra Costa County

Range Drill Suitability	Acres
Not Rated	18,991
Poorly Suited	183,983
Moderately Suited	290
Well Suited	25,563

Potential Riparian Restoration on Croplands

To determine potential for riparian restoration on croplands, the project team began by looking at the LANDFIRE Vineyard, Row Crop, Pasture and Hay, Orchard, and Cultivated Field Crops land use categories and examining intersections with known creek data. We started with the National Hydrologic dataset, but found it lacking with regard to smaller reaches of known creeks through eastern Contra Costa County. The project team then examined the California Department of Fish and Wildlife’s California Streams dataset and found a higher detail dataset, but ultimately was unable to differentiate between what was a natural riparian channel or an irrigation ditch. In Map 7 below, the California Fish and Wildlife Streams dataset is included for reference.



Map 7. Riparian Channels within Row Crop/Orchard/Vineyard Systems in Contra Costa County
Data Source: California Fish and Wildlife Streams Layer, LANDFIRE Data. Map created by Ben Weise and Johnathan Wachter.

Speaking broadly, eastern Contra Costa is dominated by two major streams: Marsh Creek (with headwaters in the Morgan Territory that flows through Brentwood and Oakley out to the Delta) and Kellogg Creek (with headwaters in the Vasco Hills and Los Vaqueros Reservoir that flows through south Brentwood, Discovery Bay, and into the Old River). Marsh Creek was dammed in the early 1960s to control the release of water, and provide flood protection in the lower Brentwood and agricultural areas. Marsh Creek and Kellogg Creek were both channelized in the 1950s for similar reasons. The end result ultimately suggests there is very little if any nexus for riparian restoration on croplands in Contra Costa County. Incidental cases may arise around Kellogg Creek or other unnamed creeks in the area, but we currently lack the data to disaggregate these true creeks from irrigation ditches and/or canals, and as such are unable to arrive at an implementation acreage and cannot complete this analysis. Future data updates that disaggregate irrigation ditches from creeks could allow this analysis to be completed.

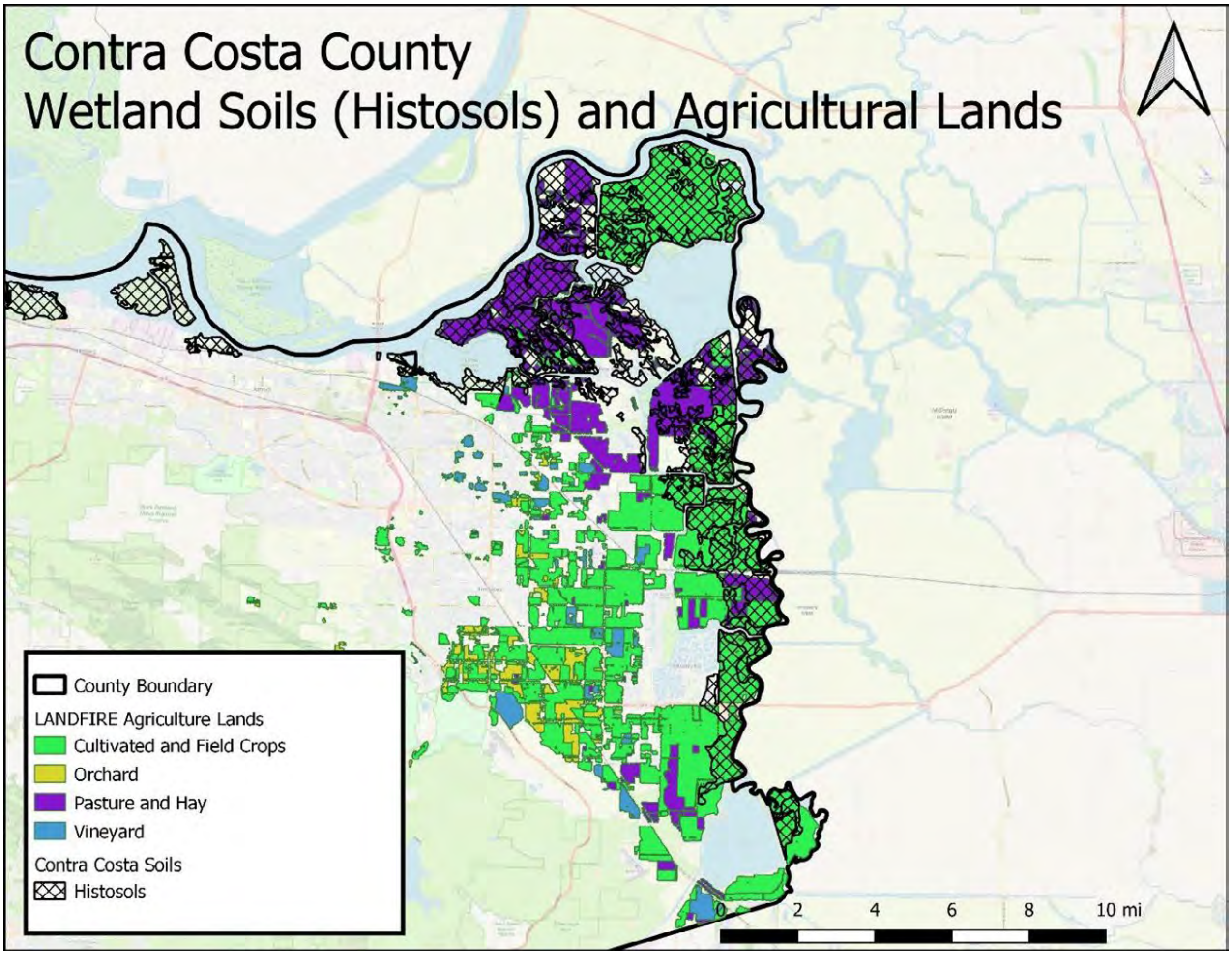
Estimating Acreage of Croplands that are on Wetland Soils

Contra Costa County is bordered by the San Francisco Bay to the north and west, and the Sacramento-San Joaquin River Delta to the east. As such, many of its coastal areas are currently or formerly wetlands. Soils forming under wetland conditions often accumulate very large amounts of organic matter because flooded conditions slow down decomposition. Here, we use soils that are classified as Histosols to indicate those areas with very high organic matter levels that were formed in wetland conditions.

Historically many wetland soils have been drained to make way for agricultural production. When a wetland soil is drained, organic matter can begin to decompose more rapidly, leading to an increase in loss of soil organic matter (carbon) from the soil. As seen in the Map 8 and Table 9 below, significant percentages of row crop, pasture and hay land in Contra Costa are found on these very high organic matter soils (Histosols) which most likely were drained to engage those production systems, primarily contained to the eastern Contra Costa islands.

Wetland soils average anywhere from 10-30% organic matter in some instances. Other soils throughout the agricultural acreage in Contra Costa County have organic matter contents that range anywhere from 1-5% on average. Modeling of climate-smart agriculture to this point has mostly been done on soils where organic matter content is in the 1-5% range and organic matter content can be increased through management practice intervention. Expected carbon sequestration potential of these modeled management practices may not apply in soils with high organic matter content like those found primarily on Sacramento-San Joaquin River Delta Islands. Map 8 below shows the location of these high OM wetland soils and where they intersect with ongoing agriculture. These high OM soils were not included in this analysis, and are included here only for informational purposes.

Drained wetland soils pose a unique opportunity. Re-wetting these soils and re-establishing wetland conditions has been shown to lead to a rapid increase in soil carbon sequestration. While the process of re-wetting can lead to a short-term increase in methane and nitrous oxide emissions, these increased emissions have been found to be quickly outweighed by the high rates of increased carbon sequestration. Extensive research has been conducted immediately north of Contra Costa County on Twitchell and Sherman Islands (Valach, et al., 2021). The project team makes no recommendations here, but raises this opportunity for wetland restoration, similar to the recently completed Dutch Slough Tidal Marsh Restoration in Oakley, CA that restored 1,100 acres of wetlands on what was formerly pasture/dairy land and the Knightsen Wetland Restoration Project in Knightsen, CA. While formerly agricultural, these lands can remain in agriculture through paludiculture, managed for the production of biomass (wetland plants, tules, reeds, etc.) for use in energy production, compost creation or other uses. Further investigation is needed, but this could be another pathway to increased carbon sequestration, primarily on wetland soils prevalent through Eastern Contra Costa County.



Map 8. Wetland Soils Maps within Contra Costa County and ongoing agricultural production Data Source: LANDFIRE Data set, Soil Survey Geographic Database. Map created by Ben Weise and Johnathan Wachter.

Table 9. Landcover type and percentage of landcover located on wetland or former wetland soils (Histosols)

Land Cover Type (LANDFIRE 2021)	Acres	Percentage on Histosols
Cultivated and Field Crops	27,342	37%
Orchard	2,162	0%
Pasture and Hay	12,143	49%
Vineyard	2,060	0.1%

Results

Using the above mentioned implementation coefficients (described in Appendix I), carbon sequestration and emissions reduction coefficients and total implementation acreage of each crop grouping, we've calculated an estimated annual carbon sequestration value for each practice and crop grouping as shown below in Table 10. An important caveat to interpretation of this table is that acreage shown should not be summed. Many of these practices are duplicative or overlapping on the same land area. Totaling the acreage would result in double counting in some cases, and therefore produce an inaccurate total estimate of sequestration and acreage potential. As an example, a farmer cannot do both "Residue and Tillage Management - No-Till" and "Residue and Tillage Management - Reduced Till" on the same field. As another example, "Cover Crop" and "Conservation Crop Rotation" are duplicative, with cover cropping potentially included in the conservation crop rotation. In practice, many of these management practices can be implemented simultaneously on the same acreage (no till and cover cropping, for example), but COMET-Planner is limited in its modeling capabilities, so we refrain from summing the tables and instead use the figures to begin a discussion of these management practices and their ability to sequester greenhouse gasses.

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Table 10. Management Practice, Implementation Acreage, and Estimated Sequestration with 100% Adoption by cropping system within Contra Costa County.

	Management Practice	Implementation Acreage	Estimated Potential Annual CO_2 Sequestered Estimate (tonne CO_2e/yr), 100% Adoption
Row Crops	Cover Cropping (CPS 340)	19186	7674
	Mulching (CPS 484)	12460	2617
	Compost Application & Nutrient Management (CPS 590)	19186	85377
	Hedgerow Planting (CPS 422)	517	4279
	Windbreak/Shelterbelt Establishment (CPS 380)	735	6090
	Riparian Forest Buffer (CPS 391)	0*	0*
	Riparian Herbaceous Cover (CPS 390)	0*	0*
	Field Border (CPS 386)	2461	3322
	Alley Cropping (CPS 311)	27342	21874
	Conservation Crop Rotation (CPS 328)	27342	7109
	Residue and Tillage Management - Reduced Till (CPS 345)	27342	2461
	Residue and Tillage Management - No Till (CPS 329)	27342	4922
Orchards and Vineyards	Cover Cropping (CPS 340)	3149	5164
	Mulching (CPS 484)	3086	1049
	Compost Application & Nutrient Management (CPS 590)	3082	14025
	Hedgerow Planting (CPS 422)	117	956
	Windbreak/Shelterbelt Establishment (CPS 380)	114	931
Vineyard	Residue and Tillage Management - Reduced Till (CPS 345)	1236	148
	Residue and Tillage Management - No Till (CPS 329)	1236	433
Orchard Only	Residue and Tillage Management - Reduced Till (CPS 345)	1513	182
	Residue and Tillage Management - No Till (CPS 329)	1513	530
	Whole Orchard Recycling (CPS 808)	2162	86
Urban Farms	Cover Cropping (CPS 340)	16	6.37
	Mulching (CPS 484)	23	4.83
	Compost Application & Nutrient Management (CPS 590)	21	94.52

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	Management Practice	Implementation Acreage	Estimated Potential Annual CO_2 Sequestered Estimate (tonne CO_2e/yr), 100% Adoption
	Hedgerow Planting (CPS 422)	1	10.69
	Windbreak/Shelterbelt Establishment (CPS 380)	5	39.41
	Field Border (CPS 386)	20	24.87
	Alley Cropping (CPS 311)	72	58.48
	Conservation Crop Rotation (CPS 328)	72	18.77
	Residue and Tillage Management - Reduced Till (CPS 345)	72	8.66
	Residue and Tillage Management - No Till (CPS 329)	72	15.88
Grazing	Compost Application to Rangelands	64299	291917
	Prescribed Grazing (CPS 528) (Rangelands)	148000	1248
	Prescribed Grazing (CPS528) (Pasture)	5450	573
	Native Oak Restoration/Silvopasture (CPS 381)	8622	5691
	Riparian Restoration	2178	19950
	Range Planting (CPS 550)	25563	8691

*See Discussion of Riparian Restoration in Row Crop Settings in the previous section

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Discussion

The analysis suggests that there is significant potential for additional carbon sequestration in agricultural lands in Contra Costa county. The numbers presented above represent an estimate of the potential for each practice in Contra Costa County agricultural lands if implemented with 100% adoption. In the real world, adoption rates are expected to be much lower. To inform some real world scenarios and prepare sequestration goals, the “Healthy Lands, Healthy People” project team met numerous times and discussed these practices at length, and provided general estimates of both current adoption broadly, and planned future adoption broadly. Some practices, like Hedgerow Installation that impacts day to day farming operations minimally, will likely see higher adoption rates. Other practices may see lower adoption scenarios, like shelterbelts, that take agricultural lands out of production and replace them with permanent woody vegetation.

Table 11 reflects the project team's current understanding of current and potential adoption rates for a variety of climate-smart agriculture management practices that could feasibly be implemented in Contra Costa county. This table is a summary of the estimated and potential adoption rates, derived from the UCCE Survey and Focus Group sessions, a poll of Contra Costa County Agriculture Technical Assistance Providers, and known applications to USDA NRCS Environmental Quality Incentives Program, CDFA Healthy Soils Program, or other non-profit programs.

Table 11. Estimated Current and Potential Adoption Rates for Management Practices by Crop Classification

Management Practice	Row Crop		Orchard Vineyard		Urban Farm		Grazing Land	
	Current	Potential	Current	Potential	Current	Potential	Current	Potential
Cover Cropping	L	H	M	H	M	H	-	-
Mulching	L	L	L	H	M	H	-	-
Compost Application	L	H	L	H	M	H	L	L
Hedgerow Installation	L	H	L	H	M	H	-	-
Windbreak Installation	L	M	M	H	L	L	-	-
Nutrient Management	M	H	M	H	L	M	-	-
Conservation Crop Rotation	L	L	-	-	M	H	-	-
Riparian Forest Buffer	L	L	L	L	-	-	M	H
Riparian Herbaceous Cover	L	L	L	L	-	-	-	-
Field Border	L	L	-	-	-	-	-	-
Alley Cropping	L	L	-	-	-	-	-	-
No-Till	L	L	-	-	M	H	-	-
Reduced Till	L	M	-	-	H	H	-	-
Whole Orchard Recycling	-	-	L	H	-	-	-	-

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Management Practice	Row Crop		Orchard Vineyard		Urban Farm		Grazing Land	
	Current	Potential	Current	Potential	Current	Potential	Current	Potential
Prescribed Grazing	-	-	-	-	-	-	M	H
Silvopasture	-	-	-	-	-	-	L	L
Range Planting	-	-	-	-	-	-	L	L

Generally speaking, Table 11 illustrates a larger point: farmers and ranchers are more likely to implement the management practice scenarios that have the least negative impact on their day-to-day operation. Many, if not most, farms and ranches are private businesses with budgets and finances with thin margins. Many of these practices, while beneficial for a number of environmental and resource concern reasons, including enhanced farm resilience in the face of climate destabilization, have very little if any immediate financial benefit and in fact have significant financial cost, or result in lower cultivated acreage.

Higher adoption rates are predicted for practices like cover cropping, mulching, compost application, hedgerow installation, and windbreak installation that do very little to interfere with a farm’s operations. Cover crops are planted either between orchard and vineyard rows and require periodic mowing/maintenance, or in row crop vegetable scenarios are planted outside the normal cropping year. Mulching and compost application are typically done prior to or after crop planting and again, don’t interfere with management of a crop. Hedgerow installation and windbreak establishment typically occur on the periphery of a field, and result in little lost cropping acreage. In a similar manner, Prescribed Grazing is a planning practice that aims to improve forage production and utilization, but requires enhanced management inputs, including tweaking pasture or range rotations, adjusting fence locations or employing new fence technology, moving and developing water sources, etc.

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Figure 9. Covered orchard floors acting as a cover crop on an Orchard in Brentwood, CA. Photo taken by Ben Weise, 2019.

Lower adoption management practices typically are classified as such because they involve some sort of economic loss, increased management, or a decrease in production acreage. Without strong economic incentives, many of these practices could cost farmers first for their implementation and maintenance, and then again through decreased revenue.

Lower adoption management practices can also be classified as such simply because there is little opportunity to implement those practices on the ground. Riparian Forest Buffer and Riparian Herbaceous Cover are typically high carbon sequestering practices when implemented. However, this analysis suggests in Contra Costa County, agriculture and riparian systems intersect very infrequently, with many if not all riparian channels heavily channelized and leveed, leaving little to any opportunity for riparian plantings without significant disruption of the current agricultural landscape. There is higher potential for these practices in grazed grasslands as part of a broader creek restoration plan, but that potential is constrained by a number of environmental factors like soil, slope, aspect, hydrology, etc. Similarly, range planting as a practice involves planting of non-native grasses and legumes for future forage, but many of the rangelands within

Contra Costa County are publicly owned and managed for open space and preservation. As such, land managers are not receptive to replacing native grasses and forbs with non-native grasses and legumes.

Nutrient Management potential is also a heavily constrained. Per the NRCS Practice Standard, the Nutrient Management practice is used to “manage rate, source, placement, and timing of plant nutrients and soil amendments while reducing environmental impacts” and typically aims to reduce synthetic nutrient application on the order of about 15%. While reducing fertilizer use has a number of co-benefits like reduced run-off, increased water quality, etc., the practice can also lead to reduced plant growth and therefore reduced sequestration as compared to had fertilizer been used. This practice is therefore typically recommended in combination (and calculated in the above tables) with compost application, as compost can compensate for the missing nutrients) while also reducing fugitive emissions from synthetic nutrients and directly increasing soil organic carbon.

One of the most surprising sequestration potential results was the potential in Alley Cropping, namely that if fully implemented on row crop agriculture, it could result in 21,874 tons of CO_2e sequestered annually. Looking critically at this practice, this would effectively result in the conversion of around nearly 5,500 acres from annual row crop land into permanent, unfertilized, woody plant cover, creating essentially strips of forest across corn, tomatoes, and other cultivated crops. Fully implemented across our practice, this would result in the loss of ~5,500 acres of row crop system and replaced with an equivalent amount trees or shrubs. An important note here is that by NRCS definition, these trees or shrubs can help diversify a farming operation, providing additional crop products provided that they don’t interfere with the row crop production (as an example, a fruit or nut tree, or berry producing shrub, could be alley cropped between rows of row crop vegetables, creating diversified revenue streams and sequestering additional carbon). Further investigation is needed to determine tree and shrub species that meet landowner goals and NRCS Standard and Specification, but as a practice, there is potential to strengthen farming operations through crop diversification and sequester significant amounts of carbon dioxide.

The final analysis the project team completed was a sensitivity analysis focused on implementation acreage. This analysis began with the 100% Adoption Rate Implementation Acreage calculation from Table 10 and divided the acreage, and resulting carbon sequestration values by 100 to derive a sequestration value associated with a 1% change in implementation acreage. This analysis was further built out with the estimated cost to achieve that 1% change in acreage, and the annual cost of the practice over the practice lifespan. The results of this sensitivity analysis are included below in Table 13.

Table 13 includes a number of assumptions. First, the implementation cost is derived from the CDFA Healthy Soils Incentives Program 2021 Payment rates which are further developed from USDA NRCS EQIP Payment rates. Second, these rates cover all of California, so actual project costs may vary, especially in the Bay Area where costs tend to be higher than in other parts of the state. These rates were pulled from the 2021 CDFA Healthy Soils Incentives Program and will likely change in the future. The goal of the sensitivity analysis was to provide estimates, and the resulting sequestration values and costs in 1% changes of the various acreages for planners.

Finally, the project team wanted to point out that while this analysis focused solely on carbon dioxide sequestration in the context of climate change, there are numerous co-benefits to many of these practices that are simply too long to list. Broadly speaking, many of these practices will improve soil health through carbon sequestration, mostly through vegetation management and the placement or growth of vegetation on parts of these agricultural properties. Through the careful selection of vegetation, many of these practices will also provide pollinator habitat (flowering cover crops and hedgerows), stormwater benefits (reduced runoff, nutrient and sediment capture, etc.) privacy benefits for landowners (decreased visibility as a result of hedgerows, living fences to prevent illegal dumping), and more. While we focus solely here on carbon sequestration, we want to mention the numerous co-benefits that are associated with these same practices.

Figure 10. A vineyard with vegetative cover acting as a cover crop. Photo taken by Ben Weise, 2018.

Table 12. Sensitivity Analysis of Contra Costa Agricultural Management Practices

	Management Practice	1% Change in Implementation Acreage	Estimated CO_2e Sequestered/Year	2021 CDFA HSP Payment Rate and Unit***	Estimated Implementation Cost	Cost per tonne CO_2e sequestered	Cost per tonne CO_2e sequestered over practice lifespan
Row Crops	Cover Cropping (CPS 340)	191.9	76.7	$102.98/acre	$19,757.62	$257.45	$257.45
	Mulching (CPS 484)	124.6	26.2	$358.32/acre	$44,645.77	$1,706.29	$341.26
	Compost Application & Nutrient Management (CPS 590)	191.9	853.8	$50.00/ton	$76,743.53	$89.89	$14.98
	Hedgerow Planting (CPS 422)	5.2	42.8	$10.32/foot	$290,381.98	$6,786.52	$199.60
	Windbreak/Shelterbelt Establishment (CPS 380)	7.4	60.9	$2.40/foot	$96,115.11	$1,578.26	$19.73
	Field Border (CPS 386)	24.6	33.2	$164.84/acre	$4,056.35	$122.10	$6.11
	Alley Cropping (CPS 311)	273.4	218.7	$2,107.20/acre	$576,150.62	$2,634.00	$175.60
	Conservation Crop Rotation (CPS 328)	273.4	71.1	$20.48/acre	$5,599.64	$78.77	$78.77
	Residue and Tillage Management - Reduced Till (CPS 345)	273.4	24.6	$28.18/acre	$7,704.98	$313.11	$313.11
	Residue and Tillage Management - No Till (CPS 329)	273.4	49.2	$31.72/acre	$8,672.88	$176.22	$176.22
Orchards and Vineyards	Cover Cropping (CPS 340)	31.5	51.6	$102.98/acre	$3,242.60	$62.79	$62.79
	Mulching (CPS 484)	30.9	10.5	$358.32/acre	$11,057.25	$1,053.88	$175.65
	Compost Application & Nutrient Management (CPS 590)	30.8	140.3	$50/ton	$12,329.93	$87.91	$87.91
	Hedgerow Planting (CPS 422)	1.2	9.6	$10.32/foot	$65,479.43	$6,852.73	$201.55
	Windbreak/Shelterbelt Establishment (CPS 380)	1.1	9.3	$2.40/foot	$14,841.56	$1,593.66	$19.92
Vine yard Only	Residue and Tillage Management - Reduced Till (CPS 345)	12.4	1.5	$28.18/acre	$348.30	$234.83	$234.83
	Residue and Tillage Management - No Till (CPS 329)	12.4	4.3	$31.72/acre	$392.06	$90.63	$90.63
Orchard Only	Residue and Tillage Management - Reduced Till (CPS 345)	15.1	1.8	$28.18/acre	$426.48	$234.83	$234.83
	Residue and Tillage Management - No Till (CPS 329)	15.1	5.3	$31.72/acre	$480.05	$90.63	$90.63
	Whole Orchard Recycling (CPS 808)	21.6	0.9	$861.42/acre	$18,623.90	$21,535.50	$1,076.78
Urban Farms	Cover Cropping (CPS 340)	0.2	0.1	$102.98/acre	$16.40	$257.45	$257.45
	Mulching (CPS 484)	0.2	0.0	$358.32/acre	$82.48	$1,706.29	$341.26
	Compost Application & Nutrient Management (CPS 590)	0.2	0.9	$50/ton	$84.96	$89.89	$14.98
	Hedgerow Planting (CPS 422)	0.0	0.1	$10.32/foot	$714.05	$6,681.62	$196.52
	Windbreak/Shelterbelt Establishment (CPS 380)	0.0	0.4	$2.40/foot	$612.34	$1,553.86	$19.42
	Field Border (CPS 386)	0.2	0.2	$164.84/acre	$33.32	$134.02	$6.70
	Alley Cropping (CPS 311)	0.7	0.6	$2,107.20/acre	$1,521.40	$2,601.48	$173.43
	Conservation Crop Rotation (CPS 328)	0.7	0.2	$20.48/acre	$14.79	$78.77	$78.77

	Management Practice	1% Change in Implementation Acreage	Estimated CO_2e Sequestered/Year	2021 CDFA HSP Payment Rate and Unit***	Estimated Implementation Cost	Cost per tonne CO_2e sequestered	Cost per tonne CO_2e sequestered over practice lifespan
	Residue and Tillage Management - Reduced Till (CPS 345)	0.7	0.1	$28.18/acre	$20.35	$234.83	$234.83
	Residue and Tillage Management - No Till (CPS 329)	0.7	0.2	$31.72/acre	$22.90	$144.18	$144.18
Grazing	Compost Application to Rangelands	643.0	2919.2	$50/ton	$257,196.00	$88.11	$4.41
Grazing	Prescribed Grazing (CPS 528) (Rangelands)	1480.0	12.5	$5.26/acre	$7,784.80	$623.81	$62.38
Grazing	Prescribed Grazing (CPS528) (Pasture)	54.5	5.7	$23.34/acre	$1,272.03	$221.88	$22.19
Grazing	Native Oak Restoration/Silvopasture (CPS 381)	86.2	56.9	$213.02/acre	$18,366.58	$322.76	$4.03
Grazing	Riparian Forest Buffer (CPS 391)	21.8	199.5	$2,999.08/acre	$65,319.96	$327.41	$16.37
Grazing	Range Planting (CPS 550)	255.6	86.9	$164.12/acre	$41,954.00	$482.71	$48.27

*Payment rate is per ton, assumed maximum implementation rate of 8 tons/acre or $400/acre.

**Payment rate is per foot, Acreage is multiplied by 43,560 square feet, then divided by 8 ft (estimated hedgerow width) to arrive at linear feet estimate.

***From CDFA 2021 HSP Payment Rates assuming lowest payment rate. Rates vary depending on scenario within practice.

Recommendations

1. *Meet agricultural producer demand where it exists.*

The USDA NRCS and Contra Costa RCD staff have worked with producers to enroll them in both the NRCS Environmental Quality Incentives Program and the CDFA Healthy Soils Incentives Program with the most popular practices being Cover Cropping, Mulching, Hedgerow Installation, Windbreak Establishment, and Compost Application on row crop and orchard/vineyard systems. Assuming a current "low" adoption rate for these practices of 8% (derived from NRCS Census of Agriculture and conversations with project team), we estimate sequestration at current levels and at additional levels of 15%, 25%, and 50%. Table 14 is a combination of the row crop, orchard/vineyard, and urban farm sequestration values.

Table 13. EQIP and HSP Popular Practices, Current Sequestration, and Potential Sequestration

	CO_2E Sequestered 8% Adoption Scenario	CO_2E Sequestered 15% Adoption Scenario	CO_2E Sequestered 25% Adoption Scenario	CO_2E Sequestered 50% Adoption Scenario
Cover Crop (CPS 340)	1027	1926	3210	6419
Hedgerow Planting (CPS 422)	420	787	1311	2623
Windbreak Establishment (CPS 380)	562	1053	1755	3511
Compost Application (CPS 808)	7952	14910	24851	49701
Mulching (CPS484)	293	550	916	1833
Total	10254	19226	32043	64086

These practices are typically grouped by Contra Costa Conservation Planners and rarely overlap or interfere with ongoing agricultural production, hence the popularity as seen on government program applications. Further support for these practices, either financially to producers or to conservation planners to meet demand would result in greater sequestration across the landscape. Under even a medium adoption scenario (25%), the resulting sequestration estimate per year is the equivalent of 6,904 gasoline-powered passenger vehicles being driven for one year (EPA Greenhouse Gas Equivalencies Calculator, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results).

2. *Rangeland Support, Restoration, and Enhancement*

Rangelands in Contra Costa County account for a significant portion of both the agriculture economic return and total agricultural acreage. In that same vein then, rangelands have an outsized role in Contra Costa County carbon sequestration potential. The most significant practice of compost application, if fully implemented in one year, would result in 291,197 tonnes of CO_2e sequestered, every year for approximately 20 years. There is also significant benefit to be gained from restoration and enhancement of riparian corridors (Riparian Forest Buffer, Riparian Herbaceous Cover),estimated at 19,950 tonnes of CO_2e/year when fully implemented.

Both these figures require ground truthing to determine actual implementation potential and sequestration values. There is significant potential in both of these practices from the carbon sequestration standpoint, and also in resource conservation, wildlife habitat created, and myriad other co-benefits from these practices. Further support to implement these practices is recommended, both in the implementation of the practice, and in supporting staff that would plan and design it.

3. *Biochar as a management practice.*

Biochar is the remaining residue after organic matter (trees, vegetation, food waste, etc.) undergoes pyrolysis, a process of heating or baking, but not combusting, organic matter. Biochar application as a soil amendment has been suggested numerous times to the CDFA for inclusion under the Healthy Soils Program, and is currently in the Environmental Quality Incentives Program (Soil Carbon Amendment, CPS 336). Further research is warranted, but researchers are interested in the porous nature of this carbon rich material that puts carbon directly into the soil and has potential to hold water and other nutrients for future release. Early research in golf courses along waterways shows biochar is able to capture nutrients before they wind up in waterways and create poor water conditions in pond and water features (provide a citation here).

As a relatively new technology, biochar is limited by its availability, namely that it is produced in very few locations, and many of the estimated greenhouse gas benefits are lost once the product is shipped over a certain distance. Still, with the exploration into new energy production technologies derived from biomass and the potential for biochar to be widely available, it is a management practice to keep an eye on. Locally, the East Bay Regional Park District has acquired a carbonator and is working to remove biomass (dead/dying trees) from East Bay Parks for processing at the Anthony Chabot Regional Park. Use of biochar as a GHG mitigation strategy requires a full lifecycle assessment of the material, including its origin, manufacturing process and receiving soil conditions.

4. Hedgerow and Windbreak Planting Support

Our analysis here focused solely on agricultural lands and the potential for hedgerows and windbreaks to be installed on them and provide mostly agricultural benefits. In reality however, hedgerows and windbreaks can theoretically be planted and built on any land use and provide similar carbon sequestration benefits. Rincon Consultants through their report recommends the creation of a Tree Study to be conducted to identify suitable locations for tree plantings throughout Contra Costa county. In that same vein, those spaces could also be utilized for hedgerows to provide other benefits. Further study is warranted and landowner goals determined as hedgerows may not meet the goals a landowner has for the property. Regardless, there is significant potential in expanding this practice beyond the confines of agricultural land uses.

Appendix

I. Implementation Coefficient Analysis
II. Calculation Table
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Appendix I. Implementation Coefficient Analysis

With management practices determined and bounds set, the project team needed to determine implementation acreages of each practice in order to run the COMET-Planner model. Typically, these practices require some level of ground-truthing on a per-farm basis, requiring multiple site visits, and conversations with the landowner to derive an “implementation acreage”. Cover crops as an example, could be, but typically are not applied across a 10-acre tomato field, but would be implemented on the rows during the off season, resulting in a reduced implementation acreage as compared to the total farm acreage. This led the team to developing implementation coefficients that were simply ratios between implementation acreage and total farm acreage.

Cover Cropping, Mulching, Compost Application, Hedgerow Installation, Windbreaks

For 5 practices (Cover Cropping, Mulching, Compost Application, Hedgerow Installation, and Windbreaks) historic CDFA Healthy Soils Incentives Program applications were utilized to determine these coefficients. The data (see Table 14) comes from actual CDFA HSP Applications that were assisted by CCRCD planners. Each practice has a specific implementation acreage per farm that is then divided by total farm acreage. These coefficients then were averaged across crop type to arrive at the management practice implementation coefficient shown in Table 15.

Table 14. Implementation Acreage for Selected Management Practices by Farm Type, derived from CCRCD Assisted CDFA Healthy Soils Program Applications

#	Farm Type	Farm Size	Cover Crop (Ac)	Windbreak (Ac)	Hedgerow (Ac)	Mulching (Ac)	Compost (Ac)
1	Urban Farm	4	1.07	-	0.19	1.19	1.07
2	Urban Farm	14.8	-	0.3	0.33	-	-
3	Urban Farm	2	0.55	0.03	0.16	-	0.55
4	Urban Farm	3	1.02	-	0.33	1.02	1.02
5	Vineyard	27	24.38	-	0.08	24.38	24.38
6	Vineyard	25	-	0.22	0.17	-	-
7	Vineyard	21	8.86	0.64	0.32	14.77	14.77
8	Orchard	2.5	1.32	-	0.22	1.89	1.89
9	Orchard	280	260	-	0.85	-	260
10	Orchard	10	-	0.07	0.08	-	-
11	Orchard	25	-	0.22	0.17	14.03	4.03
12	Orchard	5	-	0.18	0.12	-	-
13	Row Crop	7	3.19	0.0v9	0.24	3.19	3.19
14	Row Crop	9	8.53	0.22	0.17	-	8.53

Field Border

Field Borders are a practice that could feasibly be implemented in Contra Costa County agriculture, but has no historical data (EQIP or CDFA HSP) to determine implementation acreage coefficients. Field borders are defined by the NRCS as “a strip of permanent vegetation established at the edge or around the perimeter of a field.” (USDA NRCS, n.d.) To determine a coefficient, the project team started by using the median farm size in Contra Costa County. The 2017 USDA National Agricultural Statistics Service Census of Agriculture determined the median farm size is 10 acres (the average farm size was not used as it is heavily skewed upwards by a few, larger-acreage landowners at 339 acres) (USDA National Agricultural Statistics Service, n.d.). Assuming a perfectly square farm, the length of one side of the farm is 660 ft., for a total perimeter of 2640 ft. This perimeter was halved to allow unimpeded access to the middle of fields for farm equipment, etc. In other words, field borders are implemented on two edges, resulting in 1320 ft. of field borders on a 10-acre farm. Field borders can vary in width, but the NRCS Practice Standard recommends 30 ft, resulting in a total field border acreage of 39,600 square feet, or roughly 0.90 acres per 10-acre farm. The resulting coefficient then is 0.09 (0.90 acres/10 acres) and is broadly applicable to both row crops and orchard/vineyard settings. On an urban farm, the coefficient would be higher, mostly as a result of decreased-acreage. We applied the same logic, but on a 1-acre farm to arrive at the 0.28 coefficient.

Conservation Crop Rotation

Conservation Crop rotation is defined by the USDA NRCS as “a planned sequence of crops grown on the same ground over a period of time (i.e., the rotation cycle). The carbon benefits are derived from decreasing bare fallow frequency between cropland rotations, often with a cover crop or other cover. With regard to implementation acreage, it is equivalent to cultivated acreage in both the row crop and urban farm settings, resulting in a coefficient of 1.0. This practice can’t be used in orchard or vineyard settings.

Tillage Management, Reduced Till and No-Till

For tillage management practices, CDFA defines implementation acres for reduced and till and no-till as 70% of whole cultivated acreage for orchard alleys and 60% for vineyard alleys resulting in coefficients of .7 and .6. For row crops systems, the implementation acreage is the cultivated acreage for a coefficient of 1.0.

Whole Orchard Recycling

For whole orchard recycling, the implementation acreage is equal to the cultivated orchard acreage, or the coefficient is 1.0.

Alley Cropping

For Alley Cropping, the CDFA COMET-Planner requires cultivated acreage as an input. The practice itself requires removing 20% of the cultivated acreage and replacing it with woody plant cover. The CDFA COMET-Planner then calculates the sequestration value based on total cultivated acreage of the area being enrolled in this practice, although the implementation acreage would actually be 20% of the cultivated acreage. For our purposes then, we assume that cultivated acreages equals implementation acreage, despite true implementation acreage being 20% of cultivated acreage, for a coefficient of 1.0.

Riparian Practices

Finally, there are also practices that are largely dependent on surrounding land uses that will not apply to every farm. As an example, not every farm is adjacent to a riparian channel that could use a Riparian Forest Buffer or Riparian Herbaceous Cover. These implementation acreages can be derived from GIS.

Table 15. Implementation Acreage Proportions (implementation coefficients)

Management Practice	Implementation Acreage Proportion (Row Crops)	Implementation Acreage Proportion (Orchards/Vineyards)	Implementation Acreage Proportion (Urban Farms)
Cover Cropping	0.7017	0.7458	0.2206
Mulching	0.4557	0.7309	0.3188
Compost Application (C/N > 11)	0.7017	0.7301	0.2942
Hedgerow Installation	0.0189	0.0276	0.0176
Windbreak Installation	0.0269	0.0269	0.0649
Field Border	0.09	0.09	0.28
Biochar	0.7017	.7458	.2942
Conservation Crop Rotation	1.0	n/a	1.0
Reduced Till	1.0	0.6-0.7	1.0
No Till	1.0	0.6-0.7	1.0
Whole Orchard Recycling	n/a	1.0	n/a
Alley Cropping	1.0	n/a	n/a

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Appendix II. Calculation Table

	Management Practice	Implementation Acreage in Contra Costa County	Sequestration and Emissions Reduction Coefficients			CO_2e Sequestration and Emissions Reduction Coefficient (tonne CO_2e/ac/yr)	Potential Annual CO_2 Sequestered Estimate (tonne CO_2e/yr), 100% Adoption	Adoption Scenarios					Source	Expected Practice Lifespan (Years)	CDFA COMET-Planner Quantification Settings Conservation Practice, Practice Implementation, Payment Scenario
			CO_2	N_2O	CH_4			1% Adoption	8% Adoption	15% Adoption	25% Adoption	50% Adoption			
Row Crops	Cover Cropping (CPS 340)	19186	0.500	-0.100	0.000	0.400	7674	77	614	1151	1919	3837	CDFA COMET-Planner	1	Cover Crop, Add Legume SeasonaL Cover Crop to Irrigated Cropland, Multiple Species
	Mulching (CPS 484)	12460	0.210	0.000	0.000	0.210	2617	26	209	392	654	1308	CDFA COMET-Planner	5	Mulching, Add Mulch to Croplands, Wood Chips or Natural Materials
	Compost Application & Nutrient Management (CPS 590)	19186	4.630	-0.190	0.010	4.450	85377	854	6830	12807	21344	42689	CDFA COMET-Planner	6	Nutrient Management, Replace Synthetic N Fertilizer with Compost CN Ratio 15 on Irrigated Croplands
	Hedgerow Planting (CPS 422)	517	8.280	0.130	0.000	8.410	4279	43	342	642	1070	2139	CDFA COMET-Planner	34	Hedgerow Planting, Replace a Strip of Cropland with 1 Row of Woody Plants, Single Row
	Windbreak/Shelterbelt Establishment (CPS 380)	735	8.280	0.130	0.000	8.410	6090	61	487	913	1522	3045	CDFA COMET-Planner	80	Windbreak/Shelterbelt Establishment, Replace a Strip of Cropland with 1 Row of Woody Plants, Any Payment Scenario
	Riparian Forest Buffer (CPS 391)	0	1.850	0.130	0.000	1.980	0	0	0	0	0	0	CDFA COMET-Planner	20	Riparian Forest Buffer, Replace a Strip of Cropland Near Watercourses or Water Bodies with Woody Plants, Any Payment Scenario
	Riparian Herbaceous Cover (CPS 390)	0	0.610	0.020	0.000	0.630	0	0	0	0	0	0	CDFA COMET-Planner	10	Riparian Herbaceous Cover, Convert Irrigated Cropland to Permanent Unfertilized Grass/Legume Cover Near Aquatic Habitats, Any Payment Scenario
	Field Border (CPS 386)	2461	1.350	-0.120	0.000	1.230	3322	33	266	498	831	1661	CDFA COMET-Planner	20	Field Border, Convert Strips of Irrigation Cropland to Permanent Unfertilized Grass/Legume Cover, Any Payment Scenario
	Alley Cropping (CPS 311)	27342	0.800	0.010	0.000	0.810	21874	219	1750	3281	5468	10937	CDFA COMET-Planner	15	Alley Cropping, Replace 20% of Annual Cropland with Woody Plants, Tree Planting/Single Row
	Conservation Crop Rotation (CPS 328)	27342	0.260	0.000	0.000	0.260	7109	71	569	1066	1777	3554	CDFA COMET-Planner	1	Conservation Crop Rotation, Decrease Fallow Frequency or Add Perennial Crops to Rotations, Any Payment Scenario
	Residue and Tillage Management - Reduced Till (CPS 345)	27342	0.090	0.030	0.000	0.120	2461	25	197	369	615	1230	CDFA COMET-Planner	1	Residue and Tillage Management - Reduced Till, Intensive Till to Reduced Till on Irrigated Cropland, Reduced Till
	Residue and Tillage Management - No Till (CPS 329)	27342	0.180	0.040	0.000	0.220	4922	49	394	738	1230	2461	CDFA COMET-Planner	1	Residue and Tillage Management - No Till, Intensive Till to No Till or Strip Till on Irrigated Cropland, No-Till or Strip Till
Orchards and Vineyards	Cover Cropping (CPS 340)	3149	1.690	-0.050	0.000	1.640	5164	52	413	775	1291	2582	CDFA COMET-Planner	1	Cover Crop, Add Legume/Legume Mix Cover Crop to Orchard/Vineyard Alleys, Any Payment Scenario
	Mulching (CPS 484)	3086	0.530	-0.190	0.000	0.340	1049	10	84	157	262	525	CDFA COMET-Planner	6	Mulching, Add Mulch to Orchard/Vineyards, Any Payment Scenario
	Compost Application & Nutrient Management (CPS 590)	3082	4.700	-0.160	0.010	4.550	14025	140	1122	2104	3506	7013	CDFA COMET-Planner	1	Nutrient Management, Replace Synthetic N Fertilizer with Compost CN Ratio 15 on Irrigated Croplands
	Hedgerow Planting (CPS 422)	117	8.200	0.000	0.000	8.200	956	10	76	143	239	478	CDFA COMET-Planner	34	Hedgerow Planting, Plant 1 Row of Woody Plants on Border or Orchard or Vineyard, Single Row
	Windbreak/Shelterbelt Establishment (CPS 380)	114	8.200	0.000	0.000	8.200	931	9	75	140	233	466	CDFA COMET-Planner	80	Windbreak/Shelterbelt Establishment, Plant 1 Row of Woody Plants on Border or Orchard or Vineyard, Any Payment Scenario
Vineyard Only	Residue and Tillage Management - Reduced Till (CPS 345)	1236	0.090	0.030	0.000	0.120	148	1	12	22	37	74	CDFA COMET-Planner	1	Residue and Tillage Management - Reduced Till, Conventional Till to Reduced Till in Orchard/Vineyard Alleys, Reduced Till
	Residue and Tillage Management - No Till (CPS 329)	1236	0.320	0.030	0.000	0.350	433	4	35	65	108	216	CDFA COMET-Planner	1	Residue and Tillage Management - No Till, Conventional Till to No Till in Orchard/Vineyard Alleys

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	Management Practice	Implementation Acreage in Contra Costa County	Sequestration and Emissions Reduction Coefficients			CO_2e Sequestration and Emissions Reduction Coefficient (tonne CO_2e/ac/yr)	Potential Annual CO_2 Sequestered Estimate (tonne CO_2e/yr), 100% Adoption	Adoption Scenarios					Source	Expected Practice Lifespan (Years)	CDFA COMET-Planner Quantification Settings Conservation Practice, Practice Implementation, Payment Scenario
			CO_2	N_2O	CH_4			1% Adoption	8% Adoption	15% Adoption	25% Adoption	50% Adoption			
Orchard Only	Residue and Tillage Management - Reduced Till (CPS 345)	1513	0.090	0.030	0.000	0.120	182	2	15	27	45	91	CDFA COMET-Planner	1	Residue and Tillage Management - Reduced Till, Conventional Till to Reduced Till in Orchard/Vineyard Alleys, Reduced Till
Orchard Only	Residue and Tillage Management - No Till (CPS 329)	1513	0.320	0.030	0.000	0.350	530	5	42	79	132	265	CDFA COMET-Planner	1	Residue and Tillage Management - No Till, Conventional Till to No Till in Orchard/Vineyard Alleys
Orchard Only	Whole Orchard Recycling (CPS 808)	2162	0.110	-0.080	0.010	0.040	86	1	7	13	22	43	CDFA COMET-Planner	20	Whole Orchard Recycling, Whole Orchard Recycling Followed by Orchard Replant within 3 Years
Urban Farms	Cover Cropping (CPS 340)	16	0.500	-0.100	0.000	0.400	6.37	0.06	0.51	0.96	1.59	3.19	CDFA COMET-Planner	1	Cover Crop, Add Legume SeasonaL Cover Crop to Irrigated Cropland, Multiple Species
Urban Farms	Mulching (CPS 484)	23	0.210	0.000	0.000	0.210	4.83	0.05	0.39	0.73	1.21	2.42	CDFA COMET-Planner	5	Mulching, Add Mulch to Croplands, Wood Chips or Natural Materials
Urban Farms	Compost Application & Nutrient Management (CPS 590)	21	4.630	-0.190	0.010	4.450	94.52	0.95	7.56	14.18	23.63	47.26	CDFA COMET-Planner	6	Nutrient Management, Replace Synthetic N Fertilizer with Compost CN Ratio 15 on Irrigated Croplands
Urban Farms	Hedgerow Planting (CPS 422)	1	8.280	0.130	0.000	8.410	10.69	0.11	0.85	1.60	2.67	5.34	CDFA COMET-Planner	34	Hedgerow Planting, Replace a Strip of Cropland with 1 Row of Woody Plants, Single Row
Urban Farms	Windbreak/Shelterbelt Establishment (CPS 380)	5	8.280	0.130	0.000	8.410	39.41	0.39	3.15	5.91	9.85	19.70	CDFA COMET-Planner	80	Windbreak/Shelterbelt Establishment, Replace a Strip of Cropland with 1 Row of Woody Plants, Any Payment Scenario
Urban Farms	Field Border (CPS 386)	20	1.350	-0.120	0.000	1.230	24.87	0.25	1.99	3.73	6.22	12.43	CDFA COMET-Planner	20	Field Border, Convert Strips of Irrigation Cropland to Permanent Unfertilized Grass/Legume Cover, Any Payment Scenario
Urban Farms	Alley Cropping (CPS 311)	72	0.800	0.010	0.000	0.810	58.48	0.58	4.68	8.77	14.62	29.24	CDFA COMET-Planner	15	Alley Cropping, Replace 20% of Annual Cropland with Woody Plants, Tree Planting/Single Row
Urban Farms	Conservation Crop Rotation (CPS 328)	72	0.260	0.000	0.000	0.260	18.77	0.19	1.50	2.82	4.69	9.39	CDFA COMET-Planner	1	Conservation Crop Rotation, Decrease Fallow Frequency or Add Perennial Crops to Rotations, Any Payment Scenario
Urban Farms	Residue and Tillage Management - Reduced Till (CPS 345)	72	0.090	0.030	0.000	0.120	8.66	0.09	0.69	1.30	2.17	4.33	CDFA COMET-Planner	1	Residue and Tillage Management - Reduced Till, Intensive Till to Reduced Till on Irrigated Cropland, Reduced Till
Urban Farms	Residue and Tillage Management - No Till (CPS 329)	72	0.180	0.040	0.000	0.220	15.88	0.16	1.27	2.38	3.97	7.94	CDFA COMET-Planner	1	Residue and Tillage Management - No Till, Intensive Till to No Till or Strip Till on Irrigated Cropland, No-Till or Strip Till
Grazing	Compost Application to Rangelands	64299	4.660	-0.130	0.010	4.540	291917	2919	23353	43788	72979	145959	CDFA COMET-Planner	20	References for Spatial Analysis: LANDFIRE Grassland Layer Data, California Fish and Wildlife Streams Layer, County Slope Data, SSQURGO Hydric Rating, Conservation Lands Network 2.0 Vegetation Layer
Grazing	Prescribed Grazing (CPS 528) (Rangelands)	148000	0.004	0.005	0.000	0.008	1248	12	100	187	312	624	CDFA COMET-Planner	10	Prescribed Grazing, Grazing Management to Improve Rangeland or Non-Irrigated Pasture Condition, Range/Basic
Grazing	Prescribed Grazing (CPS528) (Pasture)	5450	0.051	0.054	0.000	0.105	573	6	46	86	143	287	CDFA COMET-Planner	10	Prescribed Grazing, Grazing Management to Improve Irrigated Pasture Condition, Pasture/Basic
Grazing	Native Oak Restoration/Silvopasture (CPS 381)	8622	0.660	0.000	0.000	0.660	5691	57	455	854	1423	2845	CDFA COMET-Planner	80	Silvopasture, Tree/Shrub Planting on Grazed Grasslands, Establish Trees in Existing Grasses
Grazing	Riparian Restoration	2178	9.160	0.000	0.000	9.160	19950	200	1596	2993	4988	9975	Matzek et al. 2020	20	References for Spatial Analysis: LANDFIRE Grassland Layer Data, California Fish and Wildlife Streams Layer, Conservation Lands Network 2.0 Vegetation Layer
Grazing	Range Planting (CPS 550)	25563	0.340	0.000	0.000	0.340	8691	87	695	1304	2173	4346	CDFA COMET-Planner	10	Range Planting, Seeding Forages to Improve Rangeland Condition

Appendix III. Management Practice Definitions, Descriptions, and Additional Information

Conservation Management Practice and NRCS Conservation Practice Standard	Practice Definition*
Cover Cropping (CPS 340)	Crops including grasses, legumes, and forbs for seasonal cover and other conservation purposes
Mulching (CPS 484)	Applying plant residues or other suitable materials to the land surface
Compost Application (CPS 336)	Compost application to annual crops, orchards and vineyards, and rangelands
Nutrient Management (CPS 590)	Manage rate, source, placement, and timing of plant nutrients and soil amendments while reducing environmental impacts.
Hedgerow Planting (CPS 422)	Establishment of dense vegetation in a linear design to achieve a natural resource conservation purpose
Windbreak/Shelterbelt Establishment (CPS 380)	Establishing, enhancing, or renovating windbreaks, also known as shelterbelts, which are single or multiple rows of trees and/or shrubs in linear or curvilinear configurations
Riparian Forest Buffer (CPS 391)	An area predominantly covered by trees and/or shrubs located adjacent to and up-gradient from a watercourse or water body
Riparian Herbaceous Cover (CPS 390)	Grasses, sedges, rushes, ferns, legumes, and forbs tolerant of intermittent flooding or saturated soils, established or managed as the dominant vegetation in the transitional zone between upland and aquatic habitats
Field Border (CPS 386)	A strip of permanent vegetation established at the edge or around the perimeter of a field
Alley Cropping (CPS 311)	Trees or shrubs are planted in sets of single or multiple rows with agronomic, horticultural crops or forages produced in the alleys between the sets of woody plants that produce additional products
Conservation Crop Rotation (CPS 328)	A planned sequence of crops grown on the same ground over a period of time (i.e. the rotation cycle)
Residue and Tillage Management – Reduced Till (CPS 345)	Managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year-round while limiting soil-disturbing activities used to grow and harvest crops in systems where the field surface is tilled prior to planting.
Residue and Tillage Management – No Till (CPS 329)	Limiting soil disturbance to manage the amount, orientation, and distribution of crop and plant residue on the soil surface year around.
Whole Orchard Recycling (CPS 808)	Whole Orchard Recycling Followed by Orchard Replant within 3 years
Prescribed Grazing (CPS 528)	Managing the harvest of vegetation with grazing and/or browsing animals with the intent to achieve specific ecological, economic, and management objectives.
Native Oak Restoration/Silvopasture (CPS 381)	Establishment and/or management of desired trees and forages on the same land unit
Range Planting (CPS 550)	Establishment of adapted perennial or self- sustaining vegetation such as grasses, forbs, legumes, shrubs and trees

*Definition taken from NRCS Conservation Practice Standard (CPS) Documents available through the NRCS Field Office Technical Guide.

Appendix IV. Bibliography

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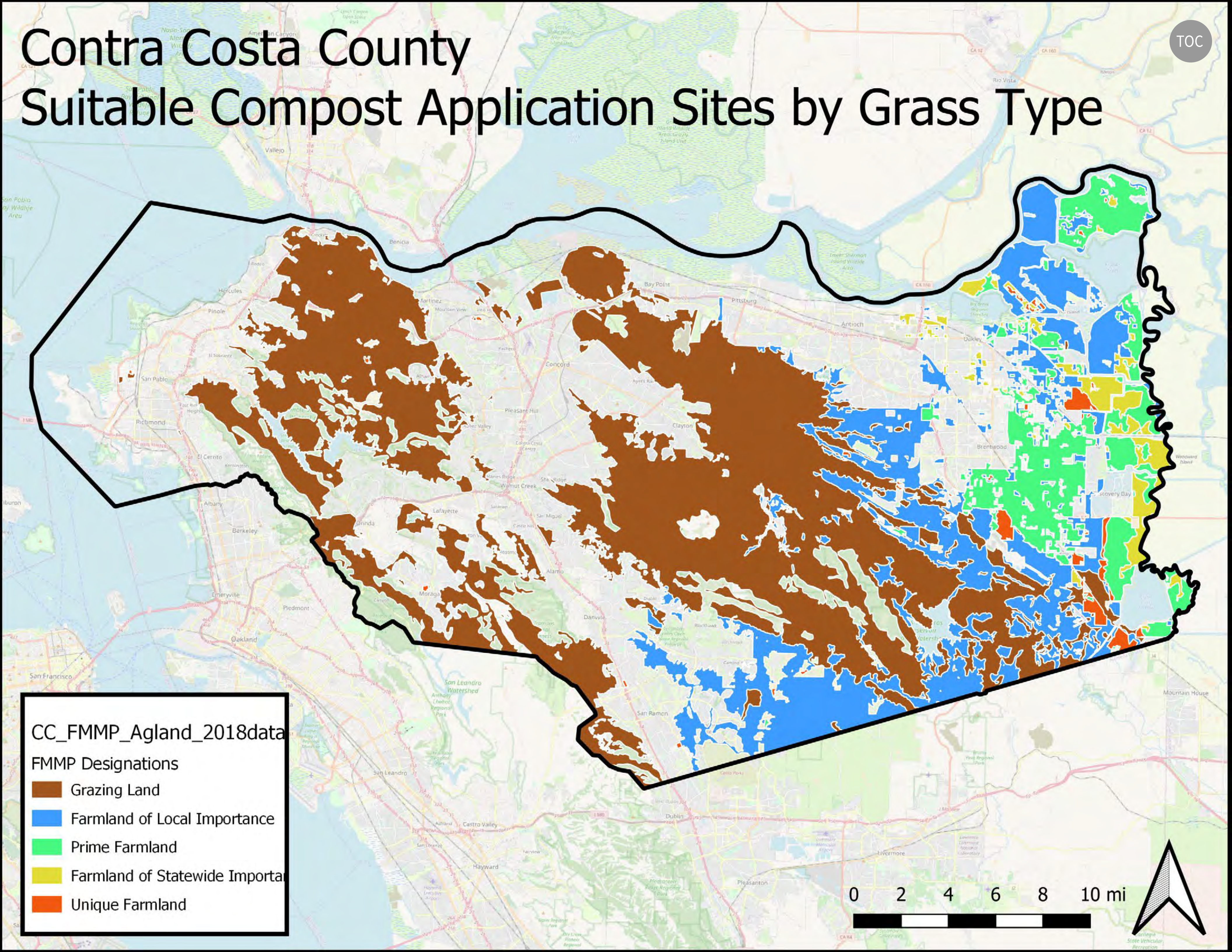
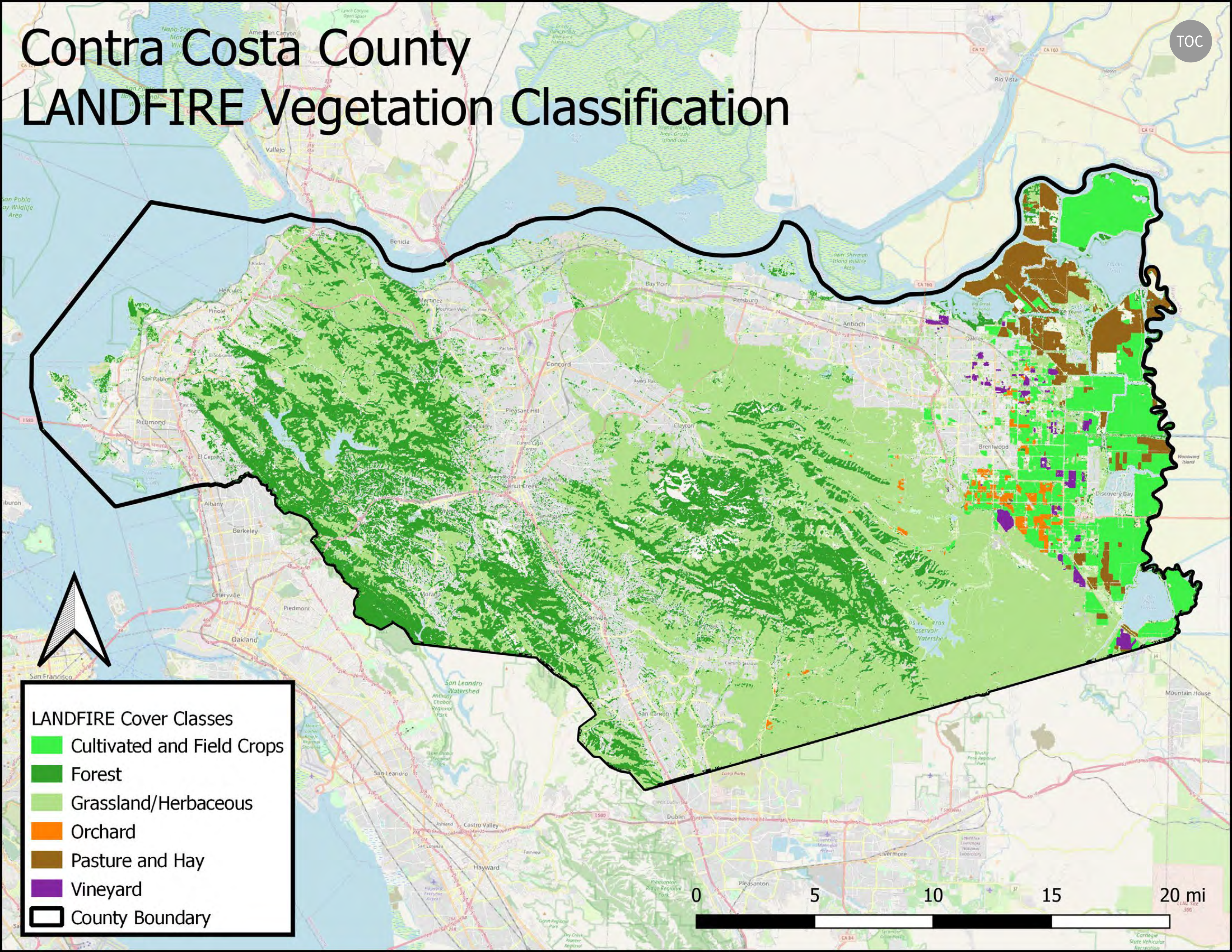
Appendix V. Full Page Maps

1. Farmland Mapping and Monitoring Program Mapped Land
2. LANDFIRE Vegetation Classification Map
3. Suitable Compost Application Areas by Grass Type
4. Oak Restoration in Grasslands (Using LANDFIRE Method)
5. Oak Restoration (using SFEI Historical Data)
6. Riparian Restoration in Grasslands Map
7. Riparian Channels in LANDFIRE Agricultural Land Map
8. Wetland Soils (Histosols) and Agricultural Lands

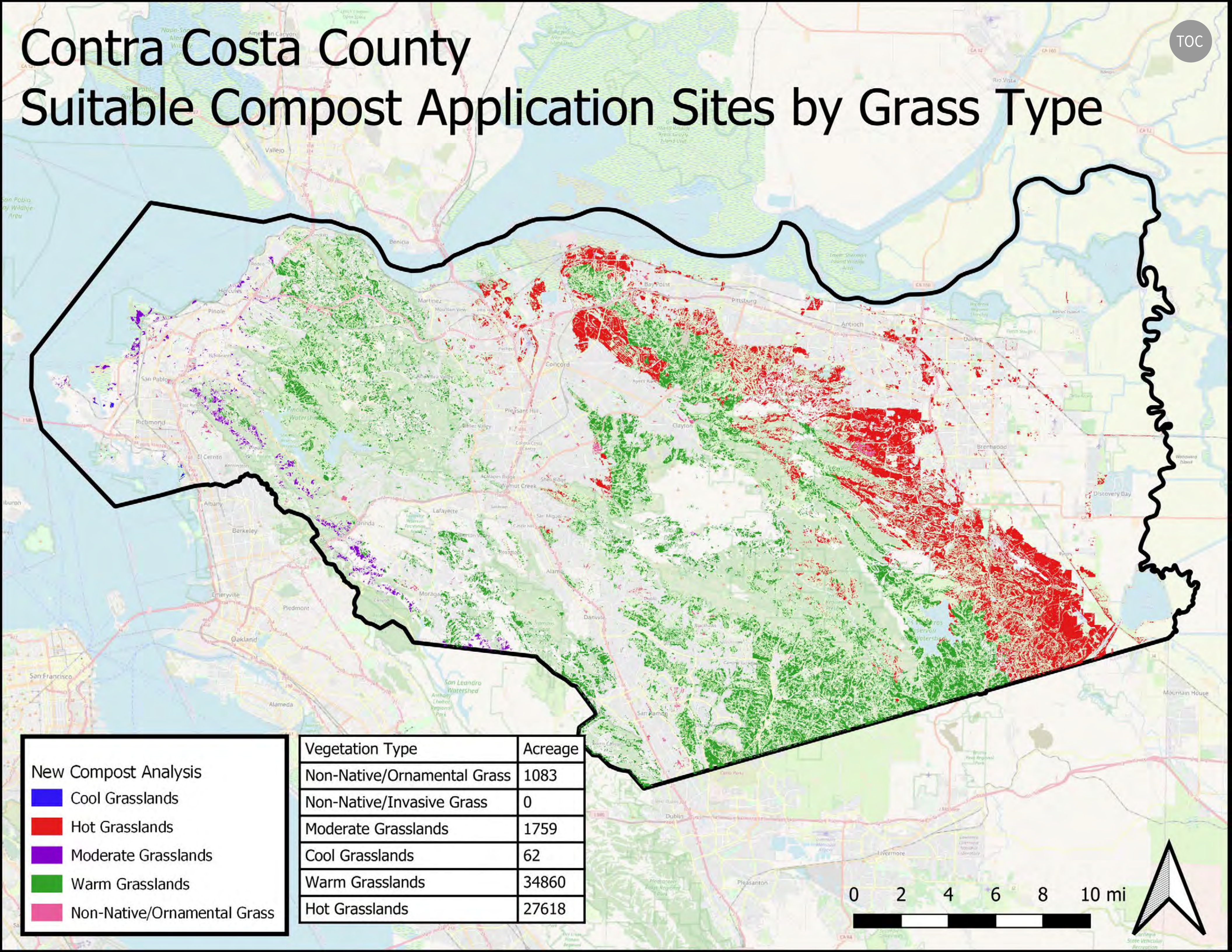

Contra Costa County
Suitable Compost Application Sites by Grass Type
TOC
CC_FMMP_Agland_2018data
FMMP Designations
Grazing Land
Farmland of Local Importance
Prime Farmland
Farmland of Statewide Importa
Unique Farmland
0 2 4 6 8 10 mi

Contra Costa County
LANDFIRE Vegetation Classification



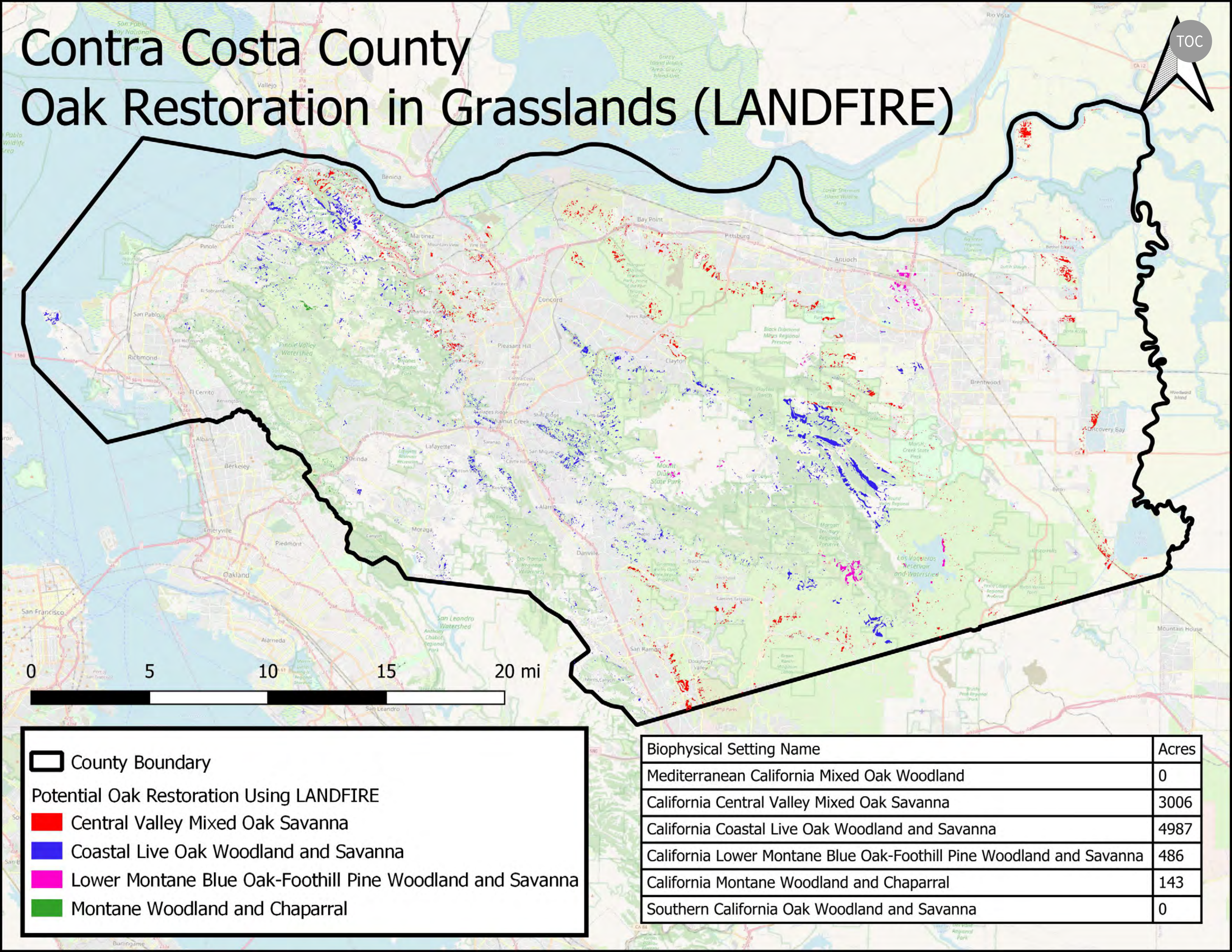
Contra Costa County
Suitable Compost Application Sites by Grass Type

TOC



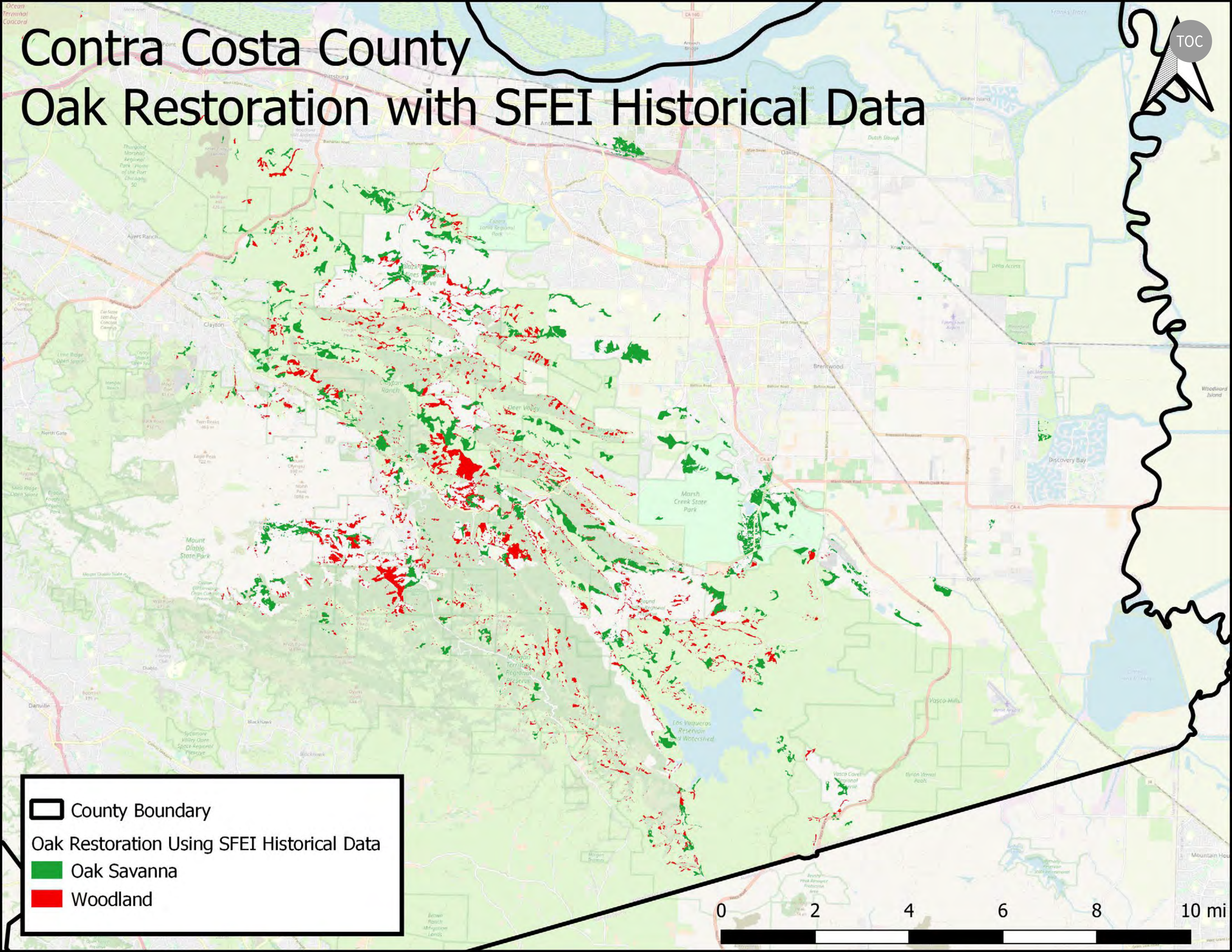
Vegetation Type	Acreage
Non-Native/Ornamental Grass	1083
Non-Native/Invasive Grass	0
Moderate Grasslands	1759
Cool Grasslands	62
Warm Grasslands	34860
Hot Grasslands	27618

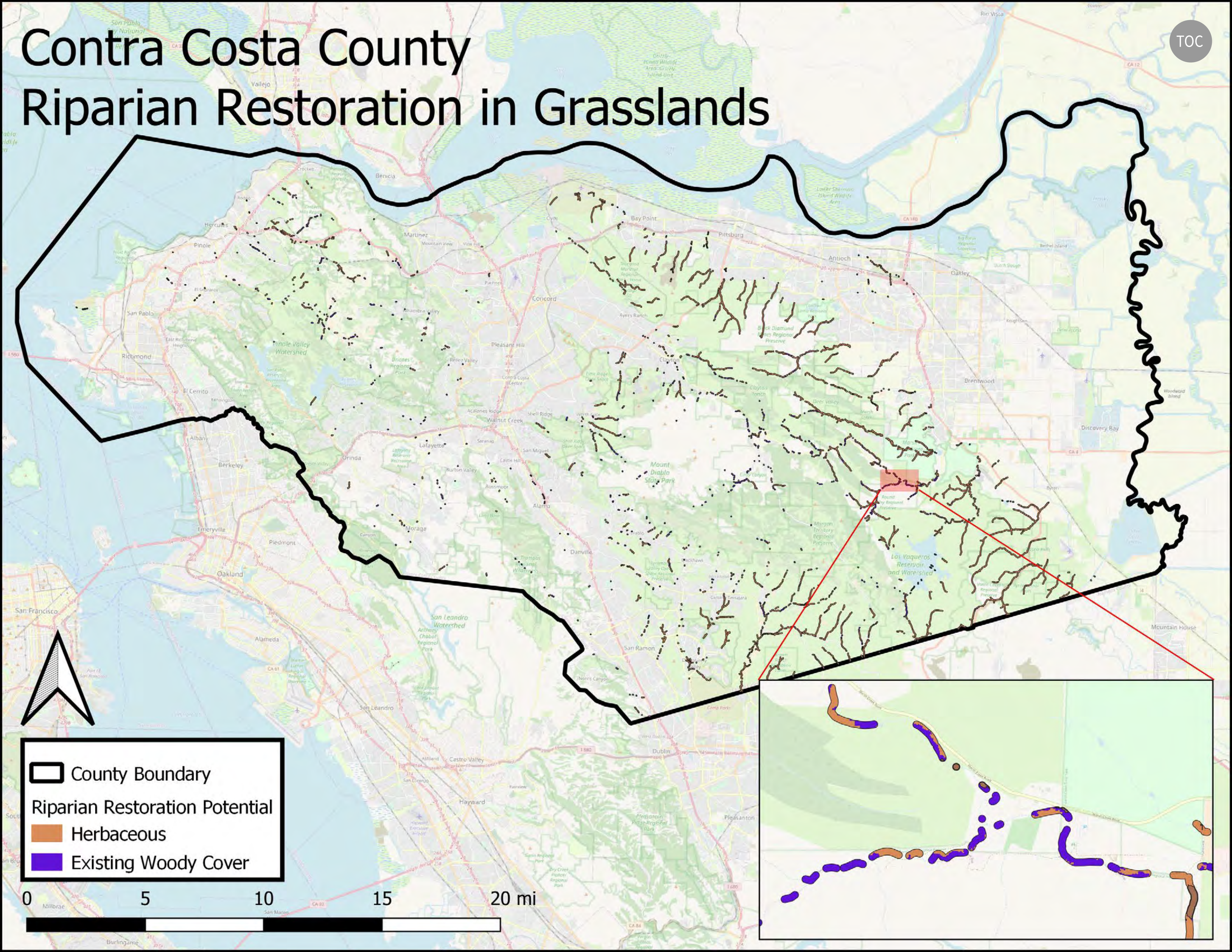
Contra Costa County
Oak Restoration in Grasslands (LANDFIRE)



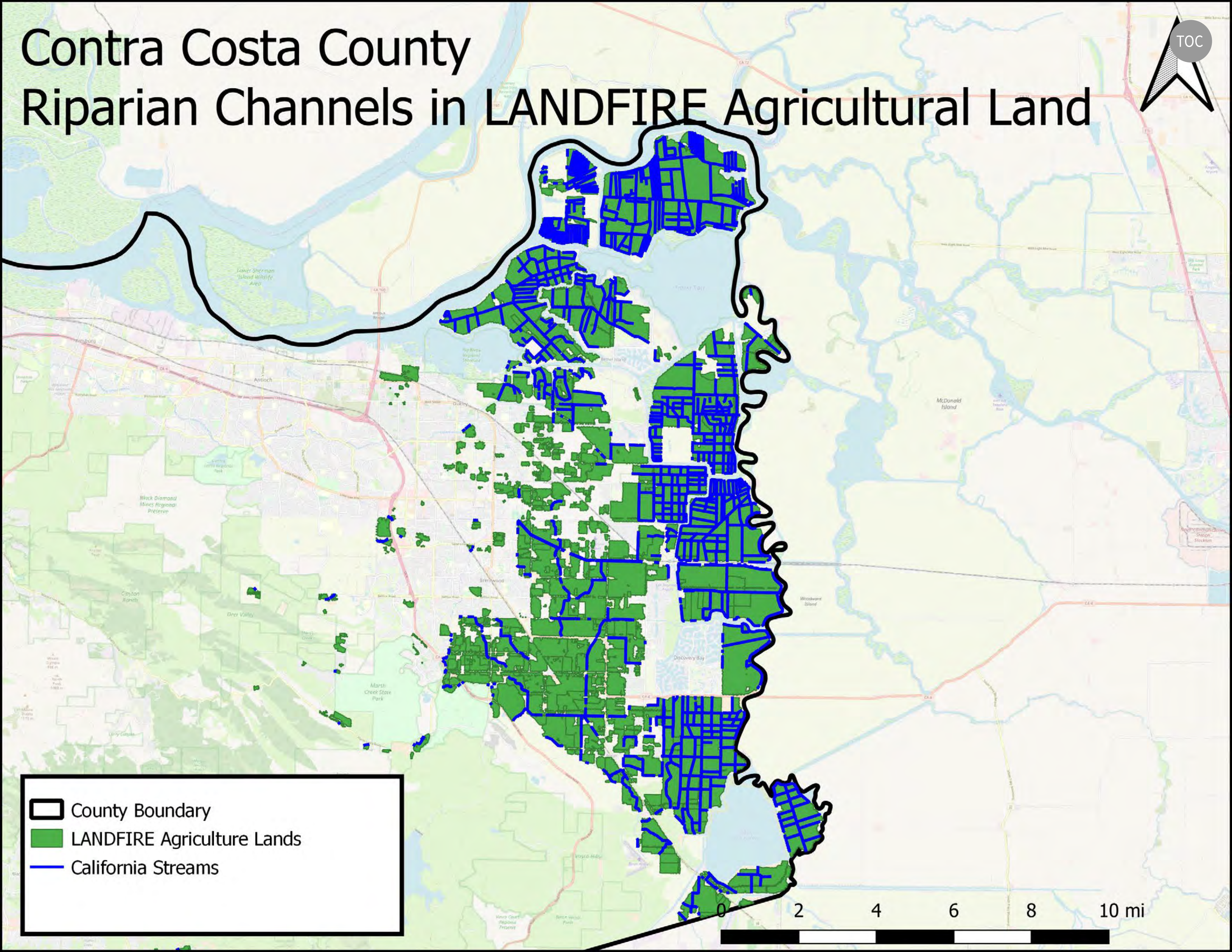
Biophysical Setting Name	Acres
Mediterranean California Mixed Oak Woodland	0
California Central Valley Mixed Oak Savanna	3006
California Coastal Live Oak Woodland and Savanna	4987
California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna	486
California Montane Woodland and Chaparral	143
Southern California Oak Woodland and Savanna	0

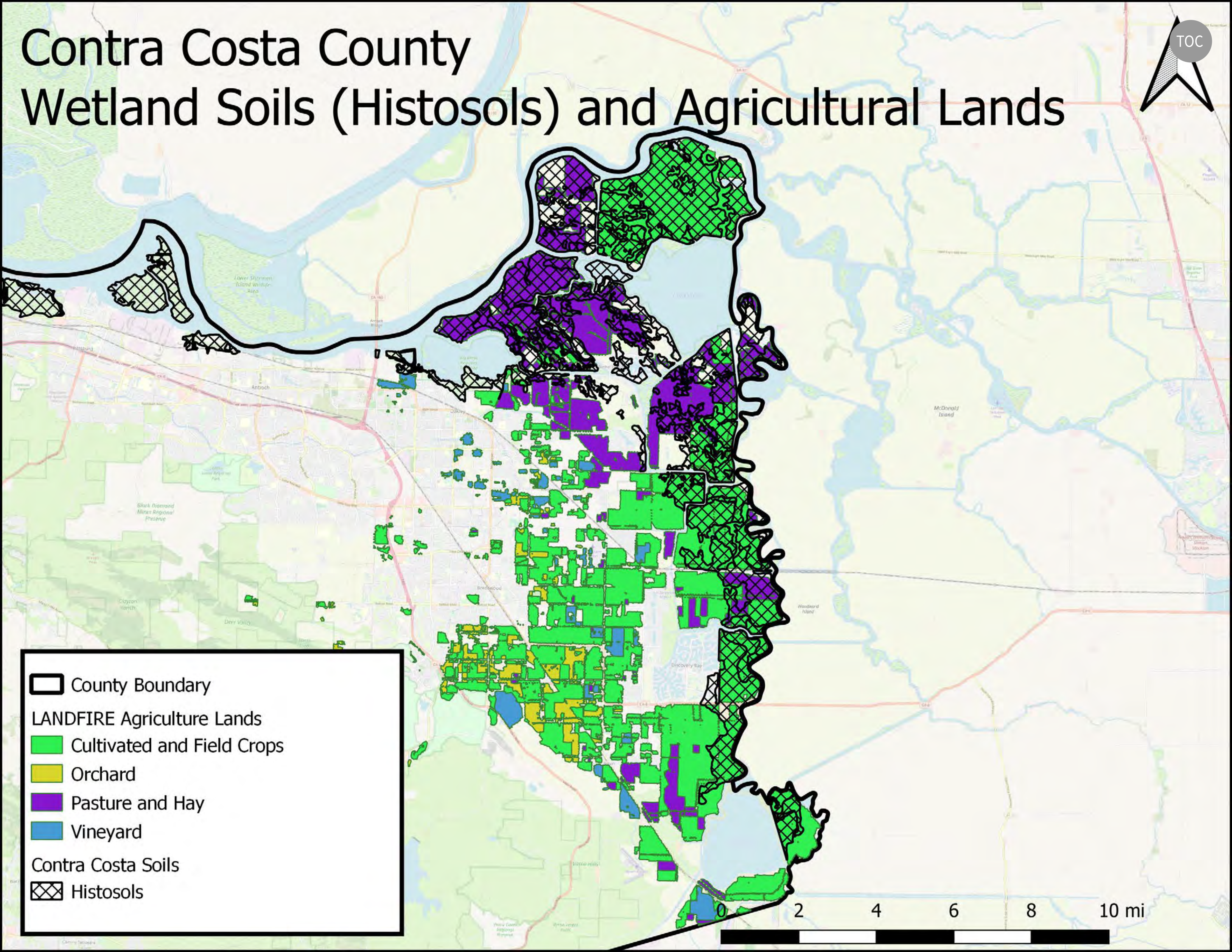
Contra Costa County
Oak Restoration with SFEI Historical Data





Contra Costa County
Riparian Restoration in Grasslands
TOC
County Boundary
Riparian Restoration Potential
Herbaceous
Existing Woody Cover
0
5
10
15
20 mi


Contra Costa County
Riparian Channels in LANDFIRE Agricultural Land
County Boundary
LANDFIRE Agriculture Lands
California Streams
0
2
4
6
8
10 mi


Contra Costa County
Wetland Soils (Histosols) and Agricultural Lands
TOC
County Boundary
LANDFIRE Agriculture Lands
Cultivated and Field Crops
Orchard
Pasture and Hay
Vineyard
Contra Costa Soils
Histosols
0
2
4
6
8
10 mi

Appendix G

Exploratory Co-Benefits Assessment

Exploratory Co-Benefits Assessment – Derived from TerraCount and the Nature-Based Solutions (NBS) Explorer Tool

Climate Smart Activity	Total Co-Benefit Score	Human Wellbeing		Water Quality /Quantity								Biodiversity								
Climate Smart Activity by Category	Sum of Co-benefits Across All Categories (+) = 1, (-) = -1, (+/-) = 0	Air Quality	Scenic Value	Urban Water Conser-vation	Improved Surface Water Storage	Improved Surface and Ground-water Quality	Ground-water Recharge/ Storage Potential	Reduced Runoff/ Erosion	Improved Flow Regime	Flood Protection	Watershed Integrity	Terrestrial Connect-ivity	Natural Habitat Area	Priority Conservat-ion Areas	Terrestrial Habitat Value	Increased Native Animal Species	Increased Native Plant Species	Natural Pest Control	Support for Local Pollinators	Aquatic Bio-diversity
Natural Lands																				
Restoration of Native Grasses[1]	11					(+)	(+)	(+)	(+)	(+)		(+)	(+)		(+)	(+)	(+)		(+)	
Oak Woodland Restoration[1]	5	(+)				(+)					(+)		(+)	(+)	(+/-)					
Riparian Restoration[1]	8	(+)	(+)	(-)		(+)					(+)	(+)	(+)	(+)	(+/-)					(+)
Compost Application[1]	10	(-)			(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Urban Lands																				
Urban Forestry[1]	6	(+)	(+)								(+)	(+)	(+)		(+)					
Agricultural Lands																				
Row Crops																				
Cover Crops[1]	9	(+)	(+)			(+)						(+)			(+)	(+)	(+)	(+)	(+)	
Mulching[1,2]	10				(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Compost Application [1,2]	10				(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Hedgerow planting[1,2]	18	(+)	(+)		(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
Windbreak Establishment[2]	8	(+)	(+)									(+)			(+)	(+)	(+)	(+)	(+)	
Riparian Forest Buffer[1,2]	12	(+)	(+)	(-)		(+)					(+)	(+)	(+)	(+)	(+/-)	(+)	(+)	(+)	(+)	(+)
Riparian Herbaceous Cover[1,2]	12	(+)	(+)	(-)		(+)					(+)	(+)	(+)	(+)	(+/-)	(+)	(+)	(+)	(+)	(+)
Field Border[2]	8	(+)	(+)									(+)			(+)	(+)	(+)	(+)	(+)	
Alley Cropping[2]	8	(+)	(+)									(+)			(+)	(+)	(+)	(+)	(+)	
Conservation Crop Rotation[2]	8	(+)	(+)									(+)			(+)	(+)	(+)	(+)	(+)	
Residue Management- Reduced Till[2]	10				(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Residue Management- No Till[2]	10				(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Orchards and Vineyards																				
Cover Crops[1,2]	9	(+)	(+)			(+)						(+)			(+)	(+)	(+)	(+)	(+)	
Mulching[1,2]	10				(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Compost Application[1,2]	10				(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Hedgerow planting2	18	(+)	(+)		(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
Windbreak Establishment[2]	8	(+)	(+)									(+)			(+)	(+)	(+)	(+)	(+)	
Vineyard Only																				
Residue Management- Reduced Till[2]	10				(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Residue Management- No Till[2]	10				(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Orchard Only																				
Residue Management- Reduced Till[2]	10				(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Residue Management- No Till[2]	10				(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Whole Orchard Recycling**	0																			
Urban Farms																				
Cover Crops[1,2]	9	(+)	(+)			(+)						(+)			(+)	(+)	(+)	(+)	(+)	
Mulching[2]	10				(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Compost Application[1,2]	10				(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Hedgerow planting[1,2]	18	(+)	(+)		(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
Windbreak Establishment[1]	8	(+)	(+)									(+)			(+)	(+)	(+)	(+)	(+)	
Field Border[2]	8	(+)	(+)									(+)			(+)	(+)	(+)	(+)	(+)	
Alley Cropping[2]	8	(+)	(+)									(+)			(+)	(+)	(+)	(+)	(+)	
Conservation Crop Rotation[2]	8	(+)	(+)									(+)			(+)	(+)	(+)	(+)	(+)	

Climate Smart Activity	Total Co-Benefit Score	Human Wellbeing		Water Quality /Quantity								Biodiversity								
Climate Smart Activity by Category	Sum of Co-benefits Across All Categories (+) = 1, (-) = -1, (+/-) = 0	Air Quality	Scenic Value	Urban Water Conser-vation	Improved Surface Water Storage	Improved Surface and Ground-water Quality	Ground-water Recharge/ Storage Potential	Reduced Runoff/ Erosion	Improved Flow Regime	Flood Protection	Watershed Integrity	Terrestrial Connect-ivity	Natural Habitat Area	Priority Conservat-ion Areas	Terrestrial Habitat Value	Increased Native Animal Species	Increased Native Plant Species	Natural Pest Control	Support for Local Pollinators	Aquatic Bio-diversity
Residue Management- Reduced Till[2]	10				(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Residue Management- No Till[2]	10				(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Rangeland and Pasture																				
Compost Application to Rangelands[1 2]	10				(+)	(+)	(+)	(+)	(+)	(+)		(+)				(+)	(+)		(+)	
Prescribed Grazing (Pasture)[2]	10				(+)	(+)	(+)	(+)		(+)		(+)			(+)	(+)	(+)		(+)	
Prescribed Grazing (Rangelands)[2]	10				(+)	(+)	(+)	(+)		(+)		(+)			(+)	(+)	(+)		(+)	
Native Oak Restoration/ Silvopasture[1 2]	13	(+)	(+)		(+)	(+)	(+)	(+)		(+)	(+)	(+)			(+)	(+)	(+)		(+)	
Riparian Restoration[1 2]	11	(+)	(+)	(-)							(+)	(+)	(+)	(+)	(+/-)	(+)	(+)	(+)	(+)	(+)
Range Planting[1]	8	(+)	(+)									(+)			(+)	(+)	(+)	(+)	(+)	

[1] Co-benefits derived from TerraCount

[2] Co-benefits derived from Nature-Based Solutions (NBS) Explorer Tool

**No co-benefits data was found in either source for this activity, row left blank for consistency of methodology; however there are co-benefits recognized in the literature for this activity.

Appendix H

California Natural Working Lands Strategies from CARB 2022 Scoping Plan

California Natural and Working Lands Strategies for Achieving Success

The California 2022 Draft Scoping Plan assesses progress toward the statutory 2030 target, while laying out a path to achieving carbon neutrality no later than 2045. Contra Costa County NWL Solutions should align with the Strategies for Achieving Success for NWL identified in the 2022 Draft Scoping Plan. The Scoping Plan describes Strategies for Achieving Success for all natural and working lands, forests/shrublands/chaparral, grasslands, croplands, developed lands, wetlands, and sparsely vegetated lands.

To evaluate the Contra Costa County Healthy Lands Healthy People initiative from the perspective of the Scoping Plan, a “Strategies Covered” column was included in the measures and actions tables below. The strategies pulled from the 2022 Draft Scoping Plan are listed below.

Natural and Working Lands

1. Accelerate the pace and scale of climate smart action, consistent with the management levels identified above, as part of a collective effort between federal, state, private, philanthropic, and individual land managers.
2. Prioritize and practice equity, including through meaningful community engagement and prioritizing implementation of nature-based solutions that benefit the communities most vulnerable to climate change.
3. Advance multi-benefit, collaborative, landscape-level approaches that engage communities and landowners, and incorporate adaptive managements.
4. PPartner with California Native American tribes to increase co-management and tribal management authority; restore and enhance natural cultural resources, traditional foods, and cultural landscapes; and support tribes’ implementing tribal expertise and Traditional Ecological Knowledges and cultural easements.
5. Leverage existing and explore new innovative financial and market mechanisms between the public, private, and philanthropic sectors to secure funding of climate smart land management.
6. In partnership with communities and the private sector, expand and develop new infrastructure for manufacturing and processing of climate smart agricultural and biomass products.
7. Leverage and support technical assistance providers: such as UC Cooperative Extension and California’s 98 Resource Conservation Districts, which have track records of providing technical assistance to local landowners and implementing agriculture, forestry, natural resource management, and restoration projects across the state.
8. Establish and expand mechanisms that ensure NWL are protected from land conversion and parcellation (e.g., conservation easements or Williamson Act).
9. Pair land conservation projects with management plans that increase carbon sequestration, where feasible.
10. Increase opportunities for private and philanthropic investments in nature-based climate solutions, utilizing existing voluntary and compliance carbon markets, existing state and local programs, and the California Carbon Sequestration and Climate Resiliency Project Registry established pursuant to Senate Bill (SB) 27.
11. Expand monitoring and tracking of management actions and outcomes consistent with the tracking and monitoring recommendations of the Climate Smart Strategy.

Forests, Shrublands, and Chaparral

1. Accelerate the pace and scale of climate smart forest management to at least 2.3 million acres annually by 2025, in line with the climate smart management strategies identified in the Draft 2022 Scoping Plan, as well as the additional strategies identified in the Climate Smart Strategy and the Wildfire and Forest Resilience Action Plan.
2. Establish and expand mechanisms that ensure forests, shrublands, and grasslands are protected from land conversion and that support ongoing, rather than one-time, management actions.
3. In collaboration with state and local agencies, accelerate the deployment of long-term carbon storage from waste woody biomass residues resulting from climate smart management, including storage in durable wood products, underground reservoirs, soil amendments, and other mediums.
4. Expand infrastructure to facilitate processing of biomass resulting from climate smart management.
5. Expand permit streamlining in collaboration with state and local agencies to accelerate implementation of climate smart forest management while protecting natural resources.

Grasslands

1. Establish and expand mechanisms that ensure grasslands are protected from land conversion/parcellation and that support ongoing, rather than one-time, management actions that improve carbon sequestration.
2. Deploy grassland management strategies, like prescribed grazing, compost application, and other regenerative practices, to support soil carbon sequestration, biodiversity, and other ecological improvements.
3. Increase adoption of compost production on farms and application of compost in appropriate grassland settings for improved vegetation and carbon storage, and to deliver waste diversion goals through nature-based solutions.

Croplands

1. Accelerate the pace and scale of healthy soils practices to 50,000 acres annually by 2025, annually conserve at least 6,000 acres of annual crops, and increase organic agriculture to 20 percent of all cultivated acres by 2045.
2. Deploy additional climate smart agricultural strategies for croplands identified in the Climate Smart Strategy (e.g., improved nitrogen use efficiency, whole-orchard recycling, riparian restoration, on-farm energy generation, and others) and utilize the recommendations included in the California Department of Food and Agriculture (CDFA) Farmer and Rancher-Led Climate Change Solutions to accelerate deployment of healthy soils practices, organic farming, and other climate smart agriculture practices.
3. Establish or expand financial mechanisms that support ongoing deployment of healthy soils practices and organic agriculture.
4. Implement the Department of Pesticide Regulation (DPR) Sustainable Pest Management Work Group recommendation to accelerate a systemwide transition to safer, more sustainable pest management.
5. Support strategies that achieve co-benefits of safer, more sustainable pest management practices and the health and preservation of ecosystems.
6. Conduct research on the intersection of pesticides, soil health, GHGs, and pest resiliency via a multiagency effort with DPR, CDFA, and CARB.

TOC

7. Conduct outreach and education to develop and facilitate the increased adoption of safer, more sustainable pest management practices and tools, reduce the use of harmful pesticides, promote healthy soils, improve water and air quality, and reduce public health impacts.
8. In collaboration with state and local agencies, accelerate the deployment of alternatives to agricultural burning that increase long-term carbon storage from waste agricultural biomass, including storage in durable wood products, underground reservoirs, soil amendments, and other mediums.
9. Work across state agencies to reduce regulatory and permitting barriers around some healthy soil practices (e.g., composting), where appropriate.
10. Utilize innovative agriculture energy use and carbon monitoring and planning tools to reduce on-farm GHG emissions from energy and fertilizer application or increase carbon storage, as well as to promote on-farm energy production opportunities.

Developed Lands

1. Increase urban forestry investment annually by 20 percent, relative to business as usual.
2. Increase public awareness of urban forests benefits and, where appropriate, prioritize irrigation of trees over lawns.
3. Provide technical assistance and resources to disadvantaged communities to implement community greening projects to provide equitable access to the benefits of greening projects.
4. Work with state and local agencies to expand technical assistance for and enforcement of the defensible space requirements of the California Public Resources Code 4291 to reduce wildfire risk to homes and structures.

Wetlands

1. Restore 60,000 acres of Delta wetlands annually by 2045 to reduce methane emissions from wetlands and reverse the resulting subsidence.
2. Deploy additional wetland protection, restoration, and enhancement activities identified in the Climate Smart Strategy, including both inland and coastal wetlands.
3. Identify and prioritize wetland restoration efforts around climate vulnerable communities.
4. Leverage other funding and institutions to support wetland restoration projects, including land trusts, local funding (e.g., San Francisco Measure AA), federal funding, and private and philanthropic funding to support wetlands restoration projects.
5. Work across state agencies to reduce regulatory and permitting barriers around Delta restoration projects, where appropriate.

Sparsely Vegetated Lands

1. Establish and expand mechanisms that ensure sparsely vegetated lands are protected from land conversion, prioritizing those areas most vulnerable to climate change and loss.

Contra Costa County

1025 Escobar Street
Martinez, CA 94553

https://www.contracosta.ca.gov/